WASTE MANAGEMENT PROBLEMS IN GEORGIA INDUSTRIES

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A. C. Merritt and C. W. Gorton

FINAL REPORT

Project E-300-101

HIGH TEMPERATURE MATERIALS DIVISION

1 July 1971

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Engineering Experiment Station

GEORGIA INSTITUTE OF TECHNOLOGY

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FOREWORD

In its simplest form pollution control can be effected through two avenues: i.e., recycling/reclamation or disposal. The first represents a long range goal while the latter represents a short range immediate solution. Of the waste disposal methods available, combustion with proper control of emission is probably the most desirable. However, the combustion of waste has been effected through traditional incineration which often contributes additional pollution problems. Through a study of the process of combustion as related to specific waste products these pollution problems may be eliminated or alleviated. In addition, suitable combustion studies should provide the data necessary to determine the effectiveness of these waste products as possible thermal energy sources. That this study is worth pursuing is indicated by the fact that in municipal refuse there is potentially available one-half the thermal energy in coal. If one considers that municipal refuse accumulates at an average rate of five pounds per person per day, simple arithmetic shows that the 3600 tons of refuse accumulated daily by Metropolitan Atlanta has the potential thermal energy value of 1800 tons of coal. This quantity of coal can produce enough electricity to supply Metropolitan Atlanta for about 9 hours. Of course such a thermal energy source could be used in other industries for the production of such items as steel and ceramics.

Municipal refuse is only one of several wastes that has a high thermal energy potential. For example, on a heat value basis, one pound of rubber tires is equivalent to one pound of coal, one pound of carpet fibers is equivalent to one and one-half pounds of coal, and one pound of wood is equivalent to slightly more than one-half pound of coal. It is interesting to note that 180,000 tons of carpet fiber waste is produced in Dalton and

Whitfield County each year. This could be considered as potentially equivalent to a coal mine which produces 540 million pounds of coal a year.

If one considers waste as a thermal energy producing resource rather than something to be discarded, this area of pollution takes on a new deminsion. With this philosophy, one might consider it indeed strange that Georgians are spending vast sums of money to cart, bury, burn and otherwise dispose of a material that might some day be considered as a valuable resource. It is with this philosophy in mind that the High Temperature Materials Division undertook this effort to determine how its expertise in the high temperature field might be applied to solving one of society's most pressing pollution problems; solid waste disposal.

J. D. Walton, Jr.
N. E. Poulos

Atlanta, Georgia
July, 1971

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The authors wish to thank the members of the Solid Waste Branch of the State Public Health Department and the Cooperative Extension Service of the University of Georgia, College of Agriculture who took the time to discuss pollution problems in the State of Georgia. Also, the authors wish to thank those in the industries contacted for their time and their cooperation. The authors wish to thank Messrs. J. D. Walton, Jr., and N. E. Poulos for their assistance and editorial comments and to acknowledge the assistance of other colleagues at the Georgia Institute of Technology, particularly members of the Industrial Development Division of the Engineering Experiment Station and the School of Textile Engineering.

I. INTRODUCTION

Over the past several years public concern for the environment and for the depletion of natural resources has grown at a rapid rate. As environmental criteria have been established, laws to control pollution have been passed, or their passage is imminent. As a result, pollution offenders have been, and will be required to cease many of their current procedures for disposal of solid, liquid, or gas wastes. For the most part, large industries and municipalities will probably be able to meet the requirements of the new laws. In many situations however, especially where small industries are involved, compliance in the time provided will be very difficult. These difficulties may occur for several reasons, but generally the economics and the technology involved are the most important parameters. Often pollution control techniques represent a considerable capital investment and operating cost. Most small industries do not have technical research staffs to solve their particular pollution problem or to optimize the economics for competing solutions to a particular waste problem. Much of the industry in the State of Georgia is relatively small and thus experiences the research limitations mentioned above. In addition, to attract new industry to an area, many small municipalities in Georgia have assumed waste disposal problems which would have been the responsibility of the industry under other circumstances.

With these facts in mind a study was recently undertaken by the High Temperature Materials Division of the Engineering Experiment Station of the Georgia Institute of Technology to delineate the waste disposal problems associated with the carpet industry, the poultry industry, and the wood products industry in Georgia. The method of approach taken to catagorize the waste disposal problems of these industries was to visit and to make preliminary case studies of specific industrial sites. This work provided a first hand knowledge of the wastes and waste disposal techniques and thus a basis for determining the associated pollution or potential pollution problems. A literature search was conducted concurrently with the site visits to determine the state-of-the-art for the disposal of specific waste materials with minimum pollution or by waste reclamation. This work also included a review of pollution abatement techniques for industrial wastes similar to the ones mentioned here in hopes of cross-application feasibility.

II. SUMMARY

The High Temperature Materials Division of the Engineering Experiment Station of the Georgia Institute of Technology undertook a survey of the pollution problems of three of the major industries of Georgia, carpet, poultry, and wood products, through a search of the literature and by individual site visits at certain industrial locations. Also, a study of the literature was made so that the technology used by other industries to eliminate pollutants similar to those identified in this study could be reviewed. Specific recommendations resulting from this survey are given below:

A. General

1. The study reported here should be continued. However it should be in more detail and of a broader scope and on an industry by industry basis.
2. Simultaneously with this study, a survey to obtain statistical information on industrial environmental loading should be undertaken.
3. Non-partisan groups should be established to serve as a general source of legal, technological and economical information regarding pollution.

B. Carpet Industry Wastes

1. The study of the combustion of waste carpet and of the furnace design for the production of energy with waste carpet fuel, or for incineration for simple disposal should be pursued.

2. The use of shredded carpet waste as a building material should be investigated, including the determination of construction properties.

3. Shredding and chopping methods for carpet waste should be studied.

4. Separation techniques for shredded carpet waste should be investigated.

5. The concept of utilization of waste carpet as a raw material for chemical processes should be emphasized. Such operations as destructive distillation and char production should be studied.

6. The possibility of a system design for the elimination of carpet dye waste by adsorption techniques possibly from char production by a facility described above should be studied.

C. Poultry Industry Wastes

1. A new material handling and storage approach for the disposal of chicken manure from the caged layer operation such that the manure is treated as a wet material should be developed.

2. The development of lethal devices or systems for fly destruction by utilizing the talents of both engineers and entomologists should be encouraged.

3. The feasibility of using manure as a raw material in the rendering operation should be considered.

4. The feasibility for the use of an adsorption facility for the cleansing of waste water and prevention odor pollution due to the waste water should be investigated.

5. A study should be undertaken to evaluate the feasibility of the disposal of chicken manure by combustion.

D. Wood Products Waste

1. A basic research effort to determine the mechanism by which particulates are formed from the fuel and entrained in the products of combustion in incinerators, tepee burners, or furnaces should be undertaken.
2. The process of odor formation in the kraft paper process for possible modifications or adaptations to the present processes for odor abatement should be studied.
3. Alternate manufacturing techniques for kraft paper production before construction of new facilities should be considered.

The capabilities of the personnel of the High Temperature Materials Division were reviewed and a series of research programs based on their interest and expertise are presented briefly. These proposed programs incorporate many of the specific recommendations listed above and would provide engineering results of immediate use. In addition, the proposed research would bridge the gap between immediate solutions to pollution problems and future solutions. The unifying thread connecting the research areas is combustion which is an important consideration in designing thermal energy sources and in producing steam or electrical energy. Also, combustion is the essential feature of incineration.

III. INDUSTRIAL WASTE PROBLEMS

The major effort in the study of the waste products and pollution problems of the industry and associated municipalities or environs within Georgia was devoted to the investigation of three of her major industries: poultry, carpet, and wood products. Investigations were begun at specific plants and in the technical literature to determine such information as type of pollutant or waste, magnitude of pollutant or waste, and the pollution abatement techniques currently in use.

Procedures used by other industries to eliminate similar wastes were reviewed. In this regard studies were conducted in less detail on such areas as the disposal of scrap automotive tires and plastics wastes and residential and commercial wastes. These areas were studied primarily by a search of the literature; however, a site investigation of a municipal waste incinerator facility was made. The concepts in the disposal of scrap automobile tires, plastic, and residential and comercial wastes will not be reported in detail in the present section of the report but will be discussed as they relate to the disposal of the waste products of interest in a later section.

A. Literature Search

As mentioned above the literature search was conducted to determine the state-of-the-art for the elimination of important industrial wastes. In addition, this permitted a brief look at the pollution abatement techniques used for disposal of wastes similar to those of interest here. The search was conducted at the Price Gilbert Library, Georgia Institute of Technology. The survey was carried out by reviewing recent abstracts including: Pollution Abstracts, Journal of the Air Pollution Control Association Abstracts, and Chemical Abstracts. Important papers identified in the review of abstracts were obtained directly from the library or were ordered from those participating in the inter-library loan service. Selected references of this literature search are given in the Bibliography on page 29. Other references are indicated as they appear in the text.

B. Carpet Industry Wastes

The case study of this industry was somewhat simplified because over 90 per cent of the tufted carpet manufactured in the United States is produced at plants within a 70 mile radius of Dalton, Georgia 1/. In addition, there is close cooperation between the local governments (Dalton City, Whitfield and Murry Counties) and the carpet industry in regard to utilities and waste disposal problems. The case study of this particular industry included a visit to the Carpet and Rug Institute (CRI). This institute is the trade association which represents a major portion of the industry. CRI is a service organization from which its members may draw technical services, marketing, and marketing research information. From this organization a basic knowledge of the type and magnitude of raw materials, principal products, and waste products associated with the industry were obtained. The carpet manufactured in the Dalton area is primarily produced by the tufted process in which a yarn filament is looped into a primary backing. The filament is then fixed to the primary backing by a layer of latex or hot melt polyester and a secondary backing, or it is fixed to the primary backing and padded in one operation by a foam backing. In the Dalton area, nylon is the principal face yarn used in the manufacturing of carpet followed in preference by acrylic fibers. The primary backing material used by the industry is made from the natural fiber, jute; but, this fiber is being replaced by man-made fibers such as polypropolene. Jute is also used as the secondary backing almost exclusively when a foam or other speciality backing is not utilized. In the carpet and rug industry in 1969 over 972 million pounds of face yarns were used 2/. From these raw materials the total industry shipped over 644,196,000 square yards of carpet or rugs of which over 564,000,000 square yards were tufted carpet. This latter value corresponds to a mill dollar value of $1,888,000,000. The principal waste products from the production of carpets and rugs are waste dye water and carpet selvage. Secondary wastes include bonding materials such as latex. Carpet selvage is the excess material trimmed from the edges of the finished carpet and thus is composed of face yarn, primary and secondary backing and the bonding agent. In 1969 the city of Dalton and Whitfield county added 944,385 cubic yards of solid waste to their landfills. Of this, over 716,000 cubic yards were attributed to the waste carpet selvage 3/.

The size of the carpet mills in Dalton spans a very broad range. Much of the industry is composed of small mills which produce only the first stage of carpet composed of undyed face yarns and primary backing. This product is then sent to a "finishing plant" where the secondary backing is attached and the carpet dyed. Other mills are very large and are completely integrated in their processing from raw material to finished salable product. One such integrated mill was visited as a part of the case study of the carpet industry because such a mill offered a complete picture of the total tuffed carpet manufacturing operation. The mill visited is one of the larger tuffed carpet mills in Dalton. The principal raw materials used by this particular mill are nylon face yarns, polypropylene primary backing, latex or hot melt polyester bonding agent, and jute secondary backing. Also included are the necessary dyes and utilities to produce a carpet. Recently the pollution problems from this particular mill have been considerably reduced, because all of the carpet selvage, or trim, comprising almost all of the solid waste is being sold to waste fiber dealers. In the past, waste carpet trim from this plant was handled by the city of Dalton as landfill. Waste trim from carpet made with a latex bonding agent is being shredded and baled before shipment. That trim with the hot melt bonding agent cannot be shredded at the mill visited with their existing machinery; however, it is still sold at a lower price than the shredded waste to a waste fiber dealer. At present, the major potential pollution problem for this company is the liquid dye waste water. Even though Dalton has a large sewage treatment facility some of the newer dispersed dyes may not be biodegradable and thus may present a pollution problem to open streams.

In summation, the pollution problems in the carpet industry of greatest importance are solid wastes from carpet selvage and liquid wastes from the dye waste water. At present there are pollution problems created by the industry but which ultimately are dispensed with by the city or county governments. There is much sentiment in the larger companies to utilize their solid waste because of the high cost of the face yarn lost to waste. If reclamation or further utilization of these materials is extended in the future, the principal pollution problems will be generated by the smaller companies which have marginal operating and expansion capital.

C. Poultry Industry Wastes

The case study of the poultry industry included the pollution problems generated by the production of eggs and by the operation of inedible rendering plants. The pollution problems associated with the production of eggs is a result of recent modifications and improvements in the procedures used to feed and maintain egg laying chickens. The new operation is called a caged layer farm. The pollution problem occurs primarily because the current manure collection systems are not efficient and thus allow the production of flies. Over the last three years, these caged layer farms have become dominant in the industry, and have increased considerably with the industry's expansion into South Georgia. The caged layer concept employes a system of automatic feeding and watering of the birds which are kept in cages staggered at various levels (usually two) in two rows along the length of the chicken house. Each cage commonly holds four birds and the bottom of the cage is gently slopped to allow the eggs to roll forward into troughs for easy collection. This concept replaces the old system where the birds were allowed to run freely inside the houses and lay eggs in roosts. In the old system, the manure drooped by the birds fell on sawdust and wood shavings. This environment produced a relatively dry mixture of manure and wood material unsuited for maggot production. In addition the free running birds consumed any maggots produced in the wetter sawdust found around watering troughs or other wet areas. The caged layer concept confines the birds over a concrete trough into which the manure drops. With caged birds, most houses have open sides for coolness. This design allows rain to enter, thus providing additional moisture and a wetter manure bed. Between 30 and 70 per cent moisture is necessary for the production of maggots and this condition is easily met on the caged layer farm. Also, the captive chickens do not provide the maggot control of the older system. In addition to the problem of fly production the current market for manure produced in the caged layer operation is limited.

Site visits were made to two caged layer chicken farms in Fayette County. The first operation visited was a moderately sized farm which usually maintained 90,000 birds in three connected chicken houses. This farm employed both automatic watering and feeding, with some feeding from a mobile feeder.

Fly control at this farm was conducted through manure removal and insecticide fogging. The manure removal procedure was accomplished by scraping the concrete troughs under the cages with a front-end loader which had been modified to clean under the cages on each side of the row. An estimated 2500 tons of manure were removed every three months and spread on nearby farmland. This operation was considered to be relatively successful in fly control and odor abatement. Another farm visited (not in operation currently) had used a mechanized scraping system to remove manure from the caged layer house daily. This procedure was not successful because it was designed to handle a dry product and thus left most of the liquid manure behind. In addition, the manure caused severe corrosion to parts of the scraping system.

The next segment of the poultry industry studied that has a high potential for pollution problems is the rendering industry. This industry provides an important service to the edible poultry industry by conversion of their wastes to saleable items such as tallow and protein meals. A major potential pollution problem related to the rendering operations is malodors. In addition, there is often a liquid waste problem in the form of bloody water which may be a source of both air and water pollution.

In the State of Georgia there are several poultry rendering plants which produce a range of products from dog food to high protein feed substitutes. As part of the present study one such plant was visited. This plant processes feathers and offal from the North Georgia, South Tennessee, and North Alabama areas and unhatched eggs from local hatchery operations. Aside from eliminating a considerable waste problem from the large edible poultry industry of the area, this plant produces primarily saleable tallow and high protein meal. In the past, the plant generated considerable odor from the liquid waste treatment ponds and from the effluent of the digesters. In addition, the return to the nearby river from the oxidation ponds had produced a water pollution problem. To correct these problems the company spent approximately $500,000 to add a liquid waste treatment facility and to add two additional aerators to the two already in operation. At the time of the site visit, this remedy was obviously effective as no odor was noticeable on the plant grounds and only a slight odor was noticeable in the office area. There was, however, still a malodor problem inside the operating plant especially in the offal and feather unloading area. The new management had been in residence for three weeks at the time of the visit and considerable work was underway, principally on weekends, to clean house, to repair leading equipment, and to modify existing equipment. Such measures were intended to eliminate the odor problem inside the operating plant. The elimination of the odor source from oxidation ponds also eliminated the water pollution problems.

In summation, the major pollution problem with two phases of the poultry industry studied are fly control and odor abatement. In certain instances, dispersal of the manure from the caged layer operation may lead to subsequent pollution problems. Also, waste water from the rendering operation may produce a water pollution problem.

D. Wood Products Wastes

The third major industrial area considered was the wood products industry. In the state of Georgia there is considerable product variety in this industry, but the majority of the operations are involved with the production of paper. For purpose of discussion, the industry may be divided into three areas: wood acquisition, wood processing, and wood finishing. The first heading primarily involves such operations as logging and saw milling. Typical wastes from this area are sawdust, slabs, and bark. The second heading includes paper production operations or cellulose fiber operations. Typical wastes from this area include bark, chips, and waste fiber. In addition wastes from these operations may include liquid waste such as sludge from the kraft process, or gaseous waste such as malodors, hydrogen sulfide and sulfur dioxide. This stage in the production of wood products constitutes the major contribution to pollution. The last heading includes wastes from operations such as cabinet shops and lumber yards. These wastes are generally highly localized.

In order to investigate in more detail the areas of wood acquisition and processing, a site visit was made to the research and development facilities of a kraft paper company. This facility is directly involved in the pollution control efforts of the company. At present, this company's pollution problems are particulate emission from its stacks and water pollution from its settling ponds. High particulate levels result from burning waste bark as a fuel. Several specific waste problems of secondary nature involve waste lime accumulation and waste wood accumulation (e.g. sawdust and bark) at remote sights. While this company did not consider its primary pollution problem to involve wastes from wood acquisition and finishing, other wood products companies do produce large quantities of solid waste materials such as sawdust and chips. The identification of the magnitude of this problem and of the disposal techniques in Georgia were not conclusive. The investigation showed that generally wood products wastes are disposed of by burning in open pits or in tepee burners or by dumping. While wood bark is a good mulching material, fresh sawdust and chips will deplete the nutriments of soils rather than replenishing them; thus, land covered with large quantities of sawdust is relatively unuseable for reforestation or agricultural use. Papers in the literature indicate that tepee burners produce smoke (particulate) and flyash.

In summary, the major pollution problems identified with the wood products industry, involve air and water pollution through the processing of wood to produce salable items. There is also a solid waste problem with wood wastes such as bark or sawdust at sawmills, which may yield pollution problems.

IV. DISCUSSIONS

In general, three approaches may be considered to eliminate or alleviate industrial pollution problems. The solution to some pollution problems may lie in the modification of the manufacturing method which would lead to a change in, or a reduction of, the pollutant waste. For other pollution problems the pollutant may be chemically or physically changed by some treatment process such that it is rendered inert (e.g. combustion of carbonaceous material to carbon dioxide and water) or as in the case of solid waste, reduced in bulk such that it is suitable for landfill. The third approach is to utilize the waste product from one operation in such a way that it becomes the starting material for other manufacturing processes which are economically feasible. In this section, current and possible pollution abatement techniques associated with the waste disposal problems identified by the investigations presented in Section III will be discussed in terms of these three approaches.

A. Carpet Wastes

In the case study of the carpet industry, two major waste disposal problems were identified. These wastes are carpet trim and dye water. The carpet trim currently presents a solid waste pollution problem because it is resilient and not readily biodegradable. The nature of the material which makes it highly desirable as a floor covering, unfortunately makes it very unsuitable as a landfill material. The waste dye water becomes a water pollution problem if it cannot be adequately treated at the municipal sewer plant. Dye wastes tint water in very low concentrations and certain dispersed dyes in use today are not biodegradable. These dyes may pass through a treatment facility unaffected and enter the water supply. At present, simple changes that could be made in the manufacturing technique to alleviate the carpet trim or waste dye problem are not obvious. The most promising possibility to alleviate these problems lies in chemical or physical modification of the wastes or in reclamation. These possibilities will first be discussed for carpet trim.

A suitable incinerator could probably be designed to burn carpet trim with existing technology; however, such an incinerator must be carefully designed to insure that it would not contribute to air pollution. Other problems associated with the softening of the waste in the feed system must also be considered. In addition, simple incineration would eliminate a solid waste that has potential as a raw material; this incineration might be attractive to the city or county governments who are charged with disposing of the waste from smaller mills.

As pointed out in Section III, several uses have been found for carpet selvage generated at the plant visited. These include the sale of shredded carpet trim to waste fiber dealers for various stuffing uses. The value of shredded waste carpet would greatly increase if some techniques were available to adequately separate the synthetic fiber from the jute and bonding material. Shredded synthetic fibers can be carded and spun into yarn just as that made from natural fibers. One operation in the Dalton area reportedly has begun only recently to affect this separation on a profit making basis by utilizing a density separation technique with a water bath. An improvement on this technique might be the use of a hydrocyclone separator. The unseparated fiber itself might well be used as a construction material for such items as acoustical tile or fiber board, especially if the mass could still be thermally set to make shaped articles. Construction properties such as acoustical resistance and thermal conductivity, must be determined before these possibilities can be considered for economic feasibility. Another area which includes chemical modification of the waste would be the formation of char or the destructive distillation of the fibers to obtain usable hydrocarbon compounds. Work is currently underway on the Georgia Tech campus to investigate char formation from other materials 4/. Destructive distillation of tires has been briefly studied elsewhere 5/ but not in terms of salable compound generation. Development of salable items from such a process would require a considerable amount of chemical engineering. In addition, this process most probably would require elevated temperatures. The energy necessary for maintaining these elevated temperatures could come from a furnace using the waste material as fuel.

The concentrations of waste dye in the effluent are usually so low that reclamation is not economically feasible even though these concentrations are sufficient to cause pollution. However, adsorption processes with compounds such as activated charcoal are capable of cleansing low concentrations from waste water. If the char were inexpensive enough so that the spent material could be disposed of rather than reclaimed this process would be more economically attractive. Charcoal made on site from waste fiber material might satisfy these criteria. In addition, charcoal is biodegradable and compactable thus making an excellent landfill material.

B. Poultry Industry Wastes

At present the edible meat production industry dumps waste water containing blood onto the feathers before shipment to the rendering plant visited. In addition, bloody water is generated at the rendering plant in processing the offal. Usually this blood is washed into the sewers. If this blood could be retained and treated, it would provide a protein source while reducing the load of organic material on the waste treatment facility. The rendering plant visited in this study has recently begun experimenting with a process to utilize the waste blood. In this process the bloody water is poured over the feathers enroute to the digesters. Air is passed through this "bed" in the hopes of coagulating the blood on the feathers. The only disadvantage of this technique is that the protein meal digested from waste which includes blood is somewhat darker which could affect product acceptance. Another technique, spray drying, has been successful in converting bloody water into a separate salable item. This technique is capable of producing a wide variety of product particle size and dryness without thermally degrading the material. However, the economic feasibility of such a procedure is highly dependent on blood concentration and may not be appropriate for the operation discussed here.

Another possibility exists for the cleansing of the waste water from the rendering plants. Adsorption on activated charcoal is well suited for cleaning low concentration wastes from water. This process has already been described for treating waste dye water and would probably operate in much the same way.

The problems of fly control in the caged layer operations can be approached in two ways, the first being the elimination of the adult fly and the second the rapid removal of the manure. Indications are that the habits of the fly are well known and thus some sort of device for killing large numbers of flies could probably be developed.

Daily elimination of the wet manure would also reduce the fly population as the breeding of maggots would be stopped. This elimination problem is a materials handling problem in which two possible avenues of approach seem feasible for initial attempts to improve manure removal. One approach is to develop automated or semi-automated mechanical devices to consolidate the manure for storage subsequent to later removal for disposal. Some such devices are in existence as described in the previous section but they do not perform satisfactorily over extended periods of time. Of course, a key concern here is the cost of installation and operation. A second approach is to form a water slurry as the manure drops and use slurry handling techniques for conveying and storage of the manure. Manure has been studied for its fuel value and for food value after treatment for bacteria.

C. Wood Products Waste

Determination of the waste and pollution problems of the wood products industry was the most difficult of the three industries. This problem was due in part to the wide variety of wood product industries in Georgia. Principal wastes in wood acquisition and wood finishing were identified to be solid waste wood materials such as sawdust. The market for packaged wood bark for mulching is growing, but the remoteness of most bark piles coupled with the high cost of packaging makes complete utilization of this waste improbable. Also, present transportation costs are too high to warrant use of these wastes as a fuel.

Current state-of-the-art disposal of these wastes by chemical modification is principally by incineration in tepee burners. Papers concerning these burners 6,7/ indicate that, when operated properly, particulate emission can be controlled. No effort was discovered by the present study in which gaseous emissions from the tepee burner were controlled. Other concepts for incineration of this type of material might be possible. Among these are fluidized bed incinerators.

In regard to reclamation concepts regarding waste wood products from all three of the characteristic wood products industries, there is some interest in the formation of activated charcoal from bark and perhaps from sawdust. In this process the volatiles driven off would be a source of gaseous fuel while reducing fly ash and other particulate from the exhaust. In past years wood was a source of methanol from a wood distillation process. This method to produce methanol is not economically attractive today; however, the sale of methanol might help to offset the cost of the disposal of the waste. A similar process might be used to produce other salable hydrocarbons, although, the feasibility of such an operation is unknown or has not been reported.

Modifications: A manufacturing technique to eliminate or alleviate the air and water pollution associated with the wood processing industry are not obvious. Chemical or physical treatment of the waste products for the elimination or reduction of resulting pollution in the wood processing industry shows some promise. The previous discussion for the elimination of fly ash and other particulate from the stack gases of boilers fired by bark fuel would well apply here. In addition the char produced in this process might be used as an adsorbant material for the elimination or reduction of the sulfur compounds (e.g., hydrogen sulfide, mercaptans, sulfur dioxide) which probably cause most of the odor associated with pulp and paper mills. Also there is some question as to the efficiency of the current industrial practices for the elimination of mercaptan formation.

Reclamation and re-utilization of wood fibers and knots removed by the screens and disposed as waste is currently underway and the developmental work includes the utilization of this fibrous material in such areas as ceiling tile and wall board.

V. RECOMMENDATIONS AND CONCLUSIONS

This section deals specifically with the recommendations and conclusions regarding some of the pollution problems associated with the industry of the state of Georgia. These are based primarily on the discussions in the previous section and are somewhat specific. The one recommendation which is general in nature but of importance is given first.

In the course of work on this project the authors encountered much ambiguity and misconception regarding industrial pollution problems due to the infancy of pollution control, research, and regulation in this state as well as the nation. One step in the solution of this communications problem would be to continue the study reported here, but in more detail and with a broader scope. Since the elimination of one pollution problem may generate another problem in another area, this study should be conducted in light of the total environment. Results of this proposed study would provide information to those charged with the protection of or investigation into the individual segments of pollution problems as well as to the industry involved. Such a study would, by its very nature, probably require several years work and considerable expense and thus would best be done industry by industry on a priority basis. Simultaneously with the study recommended above, a comprehensive survey should be conducted to provide detailed statistics on environmental loading by industry so that the quantitative input data necessary for broad-based future studies will be available as they are needed. In conjunction with this survey, the establishment of non-partisan groups which could serve as a source of information regarding legal, technological, and economical aspects of pollution and pollution control may well be required to satisfactorily communicate with those involved.

The following recommendations concern specific items regarding the individual industries studies.

A. Carpet Wastes

Carpet selvage wastes are one of the major solid waste management problems in Georgia, expecially in the Dalton area. Recommendations leading to the alleviation of this problem can be made in three areas. The first area concerns the utilization of the waste which is in essentially its current form. Specifically the recommendation is made that the use of shredded waste fiber as a building material (e.g., ceiling tile) be studied. Emphasis should be placed on the determination of the construction properties of such a material (e.g., acoustical resistance and thermal conductivity) as well as on the forming techniques such as thermal setting or felting. This recommendation emphasizes the need to develop adequate shredding or chopping devices. The second area concerns the separation of the shredded or chopped waste into a more desirable product. The recommendation is made that separation techniques, such as the hydrocyclone be studied for possible use in converting the shredded waste carpet trim into a more valuable product. The third area concerns the use of waste carpet trim as a raw material. Preliminary investigations in destructive distillation have already been conducted for scrap automobile tires. The recommendation is made that a study of this nature be conducted on pilot plant scale for carpet waste. In addition this study should go further to determine the economic feasibility for the production of a given product. This study should not be limited to just destructive distillation but might also include such operations as char production. Reclamation projects of this sort would of necessity be conducted at elevated temperature. A logical fuel for this process would be a portion of the waste itself. In order to use wastes as fuels and to design a system which would not further contribute to the pollution of the environment, a clear understanding of the combustion of the waste in the particular furnace designed would be required. This concept could well be studied as a part of the pilot plant mentioned above. In addition this knowledge of the combustion process would provide data for the disposal of carpet waste by incineration.

Waste dye water also contributes much to the potential water pollution problems from the carpet industry. The recommendation is made that an adsorption cleansing system be studied for use in the carpet industry for elimination of dye waste. This system would be particularly appealing if activated char with suitable characteristics could be manufactured from carpet trim at on site locations.

B. Poultry Wastes

Fly control and wet manure disposal are intimately linked problems in the caged layer egg operations of the state. Rapid elimination of the manure would provide some control and its ultimate removal is necessary at any rate. Thus the recommendation is made that a new approach to manure handling and storage be investigated. One such operation might be the use of a recirculating water film and closed collection tank. To ultimately eliminate the fly problem, the recommendation is made that a lethal device or system be developed for the destruction of flies. Such a project must of necessity combine engineering and entomology. Such a device or devices could be used to control flies in other agricultural operations.

Since manure disposal still remains a problem, the recommendation is made that the feasibility for converting manure into a protein feed substitute be studied. Such an operation could be performed at inedible rendering plants where the manure would serve as another raw material. The feasibility of disposing of the manure by combustion should also be investigated.

The only recommendation regarding the poultry rendering operation concerns back up treatment plants for current waste treatment facilities. The recommendation is made that the feasibility for an adsorption cleaning facility similar to that described above for the cleaning of waste dye water be studied for poultry rendering waste water.

C. Wood Products Wastes

One of the primary pollution problems identified with the wood products industry concern the production of particulate, which subsequently becomes an air pollution problem, in the burning of bark as fuel or in the burning of other wood wastes. The recommendation is made that a new process be developed for the production of a fuel source from bark while eliminating the fly ash problem. Such a process might result from concepts similar to the destructive distillation of wood to obtain methanol or the destructive distillation of scrap tires. In addition, basic research in the area of particulate formation during combustion is recommended. The concepts of gas-phase nucleation in the flue gas have been studied in some detail but the mechanism by which particles are formed directly from solid fuel and entrained in the exhaust is relatively uncertain.

One other major pollution problem in the wood products industry is the odor formation in the kraft process. This problem is by no means unexplored but its solution must be forthcoming as legislation is imminent. Since the state has several of these plants, the recommendation is made that work be initiated to determine the most feasible concepts available to eliminate this problem. Alternate manufacturing techniques for kraft paper should be studied and consideration should be given them before the construction of new facilities.

D. High Temperature Materials Division's Capabilities

In planning research efforts to aid in solving pollution problems, several approaches may be taken. One such approach would be to restrict the research to a specific discipline. That is, pollution problems associated with a given field, such as Mechanical Engineering, could be studied by individuals or groups of individuals in that particular field. This approach could well lead to the solution of specific problems in various industries but unrelated except as to the discipline involved. A second approach would be to assemble a large group of specialists and to investigate a single industry or group of industries. This approach has a certain appeal but is only realistic for very large sale efforts. A third approach is to start with individuals in one organization who have previously worked together, and to utilize their combined capabilities to attack pollution problems related to their areas of expertise.

Such a group as discussed in the third possible approach in the previous paragraph presently exists at the High Temperature Materials Division of the Georgia Institute of Technology's Engineering Experiment Station. There are personnel with expertise in Ceramic, Mechanical and Chemical Engineering who have years of experience in space-age research and technology and are currently active in this area. With these disciplines in mind the waste management problems previously discussed were reviewed so that the pollution problems in the various industries could be related to the technologies represented. Research, to obtain solutions to pollution problems associated with chemically reacting flows, will require mechanical equipment and possibly high temperature considerations and thus appears to be ideally suited to the personnel of the High Temperature Materials Division. This is not to imply that other areas of waste management are not important, but that they did not seem appropriate to the concept of the group study as previously presented.

The technical area previously referred to as chemically reacting flows is very broad and involves, in general, the use of wastes as starting materials in chemical processes, and, in particular, includes destructive distillation, the combustion process in energy generating equipment, and combustion in incineration. Because of the broad nature of chemically reacting flows, the decision was made to further restrict the area of research. In making this decision, a research area which would provide needed results for several industries was sought. In addition, this area, hopefully, would provide results of immediate use as well as bridging the gap between immediate and future solutions to pollution problems. Based on these criteria, combustion of solid wastes was selected. The combustion process may well serve as a thermal energy source for future chemical processes utilizing waste materials, it is necessary in generating energy from solid wastes, and is the essential feature of incineration. Incineration as discussed here implies the disposal of specialized wastes for which sufficient information is not presently available for design studies.

In implementing the approach formulated in the previous paragraph, it is proposed that a versatile combustion facility on a pilot plant scale be constructed. This facility would include equipment and instrumentation for preparing and studying the solid waste as fuel. Such techniques as chopping and shredding, for example, would be considered. The methods of feeding the fuel to the combustion chamber should also be considered. A combustion chamber capable of operating at high temperatures (up to 3,500°F) would be the central feature of this facility. An afterburner or afterburners would also be incorporated into the facility. Of key concern would be the equipment necessary to monitor both the gaseous and particulate emissions from the combustion process (with and without afterburning). The combustion studies would be conducted under various conditions of air flow, combustion chamber temperature, and possibly combustion chamber pressure. Suitable instrumentation would be provided so that the engineering data necessary as input for the future design of full sized installations would be obtained.

Simultaneously with the gathering of the quantitative combustion data, visual studies including high speed motion pictures of the combustion process would be conducted. These, along with a review of the data on the production of the oxides of nitrogen (during high temperature combustion) as well as other observations, could well serve to give much needed direction to more basic studies on pollution related problems. More detailed descriptions of research of interest to the High Temperature Materials Division are given in Appendix I.

In order to give an overview of the interests and activities of other units of Georgia Tech in the area of pollution, Appendix II is presented. A general description of the areas of activity are given together with names of principal researchers.

Appendix III presents biographical sketches of selected researchers at Georgia Tech who have an active interest in pollution.

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4. Private Communications Dr. M. D. Bowen.

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6. Potts, J. E., "Continuous Pyrolysis of Plastics Wastes," Industrial Wastes. 7 (8), 32 (70).

7. Fernandes, N. H. and Cohan L. J., "Industrial Waste Disposal Problem," Combustion 42 (4), 44-49 (70).

8. Walsh, R. T., "Air Pollution Aspects of the Inedible Rendering Industry," J. APCA 17 (2), 94-97 (67).

9. Colman, L. W. and Clarke, L. P., "Liquid Waste Incineration," CEP 64 (9), 83-7 (68).

10. Roberts, E. J., et al., "Solids Concentration," Chem Eng. 77, 52 (70).

11. Boubel, R. W. et al., "Wood Waste Disposal and Utilization," US PHS Bull No. 39 (58).

12. Sarkanen, K. V. et al., "Kraft Odor," TAPPI 53 (5), 766-83, (70).

APPENDIX I

PROPOSED RESEARCH AREAS

A. Comprehensive Industrial Waste Study

Since there exists today much misconception concerning pollution problems and since inadequately implemented solutions to certain pollution problems might well contribute to pollution in other forms, an extension of the study of the nature of the present report is proposed. This study should be done on an industry by industry basis beginning with the most pressing problem areas. The study should be conducted by visitation at several sites of the particular industry followed by a review of the technology available to solve the problems. An essential part of this study would be the consideration of the solutions discovered in light of their effect on the other environmental factors as well as consideration of economics and technology. Ideally this study would be conducted by personnel with a wide background oriented toward problem solving. In addition their background should include a working knowledge of the legal and biological aspects of pollution as well as the economic and technological aspects of industry.

This research would include:

1. Several site visits for each industry selected.

2. Compilation and organizing of the data obtained during the site visits.

3. A report summarizing the findings with conclusions and recommendations for pollution abatement technique or for future work to provide for an abatement techniques.

B. Combustion of Solid Industrial Wastes

The solid industrial wastes referred to here are meant to include: tires, sawdust, bark, wood chips, scrap lumber, carpet waste, chicken manure, and plastic materials. Studies have been conducted both in reclamation (destructive distillation of tires, for example) and in incineration. At present it is not clear whether destructive distillation or other forms of reclamation will prove economical. Even if reclamation processes are devised which are economical it is probable that some, if not all, of these will require elevated temperature for their operation. A logical choice of fuel for such processes could well be the solid waste material being used, so that a clear understanding of the combustion process is needed.

An essential and substantial part of a research project on the combustion of solid waste should be the physical characterization of the fuel. That is, part of the study should be concerned with the extent to which the waste should be chopped or shredded before introduction into the combustion chamber. It is well known that combustion for small particles will proceed at a much faster rate than for larger sizes if diffusion is a controlling factor in the combustion process.

This research would include:

1. DTA and TGA of typical waste materials.

2. Measurement of the heat of combustion of the waste materials.

3. Construction of a small versatile experimental combustion chamber.

4. Combustion studies of tires under various conditions of air flow, combustion chamber temperature, and fuel characteristics.

5. Theoretical studies to analytically model the combustion process so that scaling-up procedures may be developed.

C. The Generation of Solid Particulates at the Fuel-Air Interface

As is well known particulate emmisions from incinerators are one of the current pollution problems. Some of these particles are formed by gas-phase nucleation in the fuel gases while others come directly from the fuel in the form of fly ash or carbonaceous material.

Particulate emissions are especially severe during the combustion of wood wastes including sawdust, wood bark, and waste wood slabs.

The purpose of the research to be proposed here is to perform a basic study to study the mechanism by which such particles are formed and subsequently entrained in the exhaust gas from the combustion of wood products.

This research would include:

1. High-speed motion picture studies of burning wood wastes under various combustion conditions.

2. Measurement of particulate emissions during the studies described in "1" above.

3. Theoretical studies based on the results of the above in an attempt to quantitize the particulate emission mechanism.

D. The Production of the Oxides of Nitrogen During Combustion

Nitric oxide (NO) and nitrogen dioxide (NO_2) may be formed during a combustion process in air at sufficiently high temperatures. Usually the concentration of NO is much higher than that of NO_2. However, the nitric oxide in the atmosphere in the presence of sunlight may then oxidize to nitrogen dioxide. The presence of the dioxide in the atmosphere has been shown to be necessary for the production of photochemical smog. Even in regions of the country where photochemical smog is not a problem, the dioxide undesirable and in concentrations greater than about 5 ppm. has been shown to constitute a health hazard.

During the combustion of solid fuels the high temperature regions may be very close to the burning surfaces and the production of nitrogen oxides is probably favorable there. The temperature of the flue gases may be lowered by using excess air but the temperature of the hot zones is not expected to vary in direct proportion to the amount of excess air. The primary goal of the research to be proposed here is to study the relationship between the combustion chamber conditions and the production of the oxides of nitrogen (NO and NO_2). This study would aid in evaluating situations in which high temperature incineration offers a possible solution to solid waste management problems.

The research will include:

1. Combustion studies of solid wastes under various conditions of air flow and fuel characteristics.

2. Measurement of the oxides of nitrogen in the exhaust gases.

3. Development of analytical models to determine the important parameters of oxide production as related to combustion chamber conditions.

E. Use of Carpet Waste in the Manufacture of Construction Materials

Fibers from carpet waste can be used in a felting operation to produce acoustical tile and other building construction materials. For the production of acoustical tile, natural fibers which rot will not be desirable so that some type of separation technique will have to be developed. For other building materials it might be feasible to include synthetic carpet backing as well as fiber if the material is finely chopped or shredded.

The purpose of the research proposed here is to obtain design information on the felting operations obtained from production on a laboratory scale of acoustical tile and other building materials. The personnel of the High Temperature Materials Division has a large amount of experience in making ceramic acoustical tile and other felted products.

This research would include:

1. Production of acoustical tile.

2. Production of building materials using various sizes and shapes of the shredded and/or chopped carpet waste.

3. Evaluations of the materials produced, including at least the acoustical properties of the tile and the thermal conductivity of the building materials. Other properties may be measured as well.

F. Size Reduction of Carpet Waste

Although much technology exists for size reduction in the chemical process industry, little seems to have been done in the carpet industry in studying chopping and shredding techniques for the solid waste. Some difficulties have been experienced in the heating of the blades of chopping devices which results in the softening of the polyester hot melt bonding agent resulting in the failure of the chopping process.

Size reduction is an important consideration in preparing carpet waste as raw material for use in stuffing, construction materials, and for combustion. Although the work to be proposed here will be restricted to carpet waste, it is expected that some of the research will be directly applicable to other solid wastes as well.

It is proposed that an engineering oriented research effort be undertaken which would consist of the following:

1. A review of the state-of-the-art in size reduction techniques generally applicable to carpet waste.

2. Selection of those techniques which appear particularly promising from the review.

3. Experimental evaluation of the selected techniques for use in size reduction of carpet waste.

4. Investigate modifications based on the experimental work to optimize, the performance of the size reduction devices.

G. The Use of the Hydrocyclone in Separating Carpet Waste Components

After the carpet waste has been chopped and/or shredded some means of separating the fibers from the other waste is needed before the fibers can be reused. Although it is anticipated that the carpet waste studied in this research effort would be chopped or shredded, this requirement does not necessarily imply that a study on chopping and shredding carpet waste must be done first. If necessary, the chopping and shredding could be done by hand for the proposed study. The optimum form of the carpet waste after size reduction could be based on the results of the hydrocyclone study. Ideally, however, it would appear that concurrent studies would be best.

Some success has been realized with a gravity water flotation method of separating carpet waste and has prompted the work proposed here. A hydrocyclone is a device which is widely used in the paper and mining industry to separate materials of different specific gravities and utilized the centrifugal field in the rotary fluid to speed up the separation process.

This research would include:

1. The construction of a hydrocyclone facility.

2. A parametric study of the operating characteristics of the hydrocyclone for typical carpet waste with various conditions of feed material.

3. Correlation of the experimental data to optimize the operating conditions for each feed material.

H. Slurry Manure Handling System

One step toward the elimination of fly production in the caged layer operation would be the rapid removal of manure. Current techniques used by the industry are primarily designed to handle a dry material and are often the homemade design of the individual farmer. Material handling problems of great variety are solved economically in the chemical process industry. Applications of the concepts developed there might well provide an inexpensive manure collection system. Since manure has potential utilization in other areas such as fertilizer or feed substitute, the collection system should include a storage system that would provide for easy handling to another process.

One design that might prove successful for rapid and inexpensive manure removal would incorporate a liquid film of water for collection of the manure as a slurry and transportation to a storage facility where the manure would be separated from the slurry and the water treated and recycled. Such a design must include the overall chicken house floor design and provide for practical problems such as feed spillages and rain in. This concept could possibly be developed as a small scale demonstration model and should include enough flexibility to be installed, full scale, in existing operations as well as new installations.

This research would include:

1. The construction of a small test facility.

2. The evaluation of various test parameters including trough roughness, trough coatings, angle of inclination of the trough, and water rate.

3. An economical projection based on the above results so that the cost of installing and operating a full size unit could be determined.

APPENDIX II

SUMMARY OF SELECTED PROGRAMS AT GEORGIA TECH RELATED TO WASTE MANAGEMENT

The following list of selected waste management related activities illustrates the scope of interest in this field at Georgia Tech.

1. Problems related to pollution from automobile engine emissions are being studied by Dr. S. V. Shelton of Mechanical Engineering.

2. Research concerning the pollution hazards from the burning of wood products waste has been carried out by Dr. J. H. Burson, III of Chemical Engineering.

3. Fine particle research related to particulate pollution is being conducted by Dr. Clyde Orr, Jr., Dr. M. J. Matteson, Dr. J. H. Burson, III, and Mr. E. Y. H. Keng of the Micromeritics Branch of the Chemical Sciences and Materials Division.

4. Graduate level course work in the Georgia Tech Air Quality Control Program is being taught by Professors M. J. Matteson and J. H. Burson, III of Chemical Engineering, Professor T. W. Kethley of Biology, Professor P. E. Sturrock of Chemistry and Professors Richard King and F. G. Pohland of Civil Engineering.

5. A program which has just been initiated at the Engineering Experiment Station is concerned with utilization of specific waste materials of Georgia and their conversion into useful materials. This program is under the leadership of Drs. M. D. Bowen and J. A. Knight, Jr.

6. Water pollution and associated problems related to environmental quality and resource management are subjects of study at the Environmental Resources Center, Professor Carl E. Kindsvater, Director.

7. Water pollution research as related to sewage disposal is being conducted by Dr. R. S. Ingols of the Chemical Sciences and Materials Division.

8. The interaction of water with organic species as related to water pollution is being studied by Dr. C. L. Liotta of Chemistry.

APPENDIX III

BIOGRAPHICAL SKETCHES OF SELECTED RESEARCHERS INTERESTED IN WASTE MANAGEMENT

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

BOMAR, STEVE H., Jr.--Head of Fundamentals Branch,
High Temperature Materials Division,
Engineering Experiment Station

Education

B.Ch.E., Georgia Institute of Technology	1959
M.S.Ch.E. Georgia Institute of Technology	1961
Ph.D. in Ch. E. Georgia Institute of Technology	1967

Employment History

Continental Oil Co., Student Process Engineer	Summers of 1957, 1958
U.S. Army, First Lieutenant and Captain	1965-1967
Georgia Institute of Technology	
Student Instructor	1958
Student Assistant	1958-1959
Research Assistant	1959-1965
Research Engineer	1967-1968
Senior Research Engineer	1968-Present
Supervisor of Fundamentals Section	1967-1968
Head of Fundamentals Branch	1968-Present

Experience Summary: Taught freshman chemistry laboratories at Georgia Tech and worked on characterization and production of complex shapes of slip-cast fused silica. Worked on study of chemical reactions in aluminum-uranium oxide system with emphasis on production of nuclear reactor fuel elements capable of high temperature operation. Also studied hazards associated with use of uranium oxide dispersions in aluminum. Worked on impregnation of felted ceramic systems with water bearing materials for transpiration cooling. Studied use of thin metal films as thermometers and heaters in heat transfer investigations. During active duty in Army worked on devices for protection of personnel against laser radiation and production of lanthanide (rare earth) metal alloy thin films.

Current Fields of Interest

Development of high purity silica systems; development of materials resistant to high-intensity radiation; simulation of rain erosion on materials; nucleation phenomena in solids, chemical vapor deposition.

Major Reports and Publications

1. "Materials for High Temperature Nuclear Engineering Applications," Reports on U. S. Atomic Energy Commission Contract No. AT-(40-1)-2483, 1962-1964, coauthor
2. "Reactions in Al-34w/oU_3O_8 Dispersions," TID-21311, U. S. Atomic Energy Commission, July 1964, coauthor
3. "Ceramic Systems for Missile Structural Applications," Reports on Department of the Navy, Bureau of Naval Weapons Contract No. NOw-63-0143-d, 1964-1965, coauthor

Major Reports and Publications (Continued)

4. "Heat Transfer from Electrically Heated Thin Metal Films to Water in Pool Boiling," Ph.D. Thesis, Georgia Institute of Technology, Atlanta, June 1967
5. "High-Strength, Broadband, Lightweight Silicon Oxide Radome Techniques," Technical Reports on U. S. Air Force Contract No. F33615-67-C-1594, 1967, coauthor

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

BURSON, JOHN H., III -- Associate Professor and Senior Research Engineer

Education

B. Ch.E., Georgia Institute of Technology	1956
M. S. Metallurgy, Georgia Institute of Technology	1963
Ph.D., Georgia Institute of Technology	1964

Employment History

Testworth Laboratories, Carrollton, Georgia	1956 - 1959
Chief Chemist	
U. S. Army Chemical Corps, Active Duty	1957
Georgia Institute of Technology	
Research Assistant	1959 - 1962
Assistant Research Engineer	1962 - 1965
Senior Research Engineer	1965 - Present
Associate Professor of Chemical Engineering	1968 - Present

Experience Summary: Chief chemist for Testworth Laboratories from January 1956 to September 1959, exclusive of U. S. Army service. While at Testworth, directed research programs leading to the development of various types of dispersions, emulsions, and latex-based protective coatings. Considerable time was also spent in technical service. Returned to Georgia Tech in September 1959 as a full-time employee of the Engineering Experiment Station and a part-time graduate student. Since returning to Georgia Tech has been engaged in research on a variety of subjects including separation and classification by size of particulate matter; methods of particle size measurement; the effects of electrostatics on particulate properties; the development of high-density slurries for hydrostatic testing of missile fuel tanks, environmental pollution and biomedical engineering. Presently is principle investigator for research grants on studies of particle dynamics and of the thrombogenic characteristics of ceramics as vascular implants. Has taught courses in the School of Chemical Engineering on General Metallurgy, Corrosion, Chemical Engineering Calculations (Stoichiometry), Colloid Science and Polymer Technology, Computer Applications in Chemical Engineering, Industrial Emission Control, and Comprehensive Problems. Listed in American Men of Science and Marquis' Who's Who in the South and Southwest. Member, American Institute of Chemical Engineers, American Chemical Society, National Society of Professional Engineers, The Fine Particle Society, and Society of Sigma Xi. National President of the Fine Particle Society and Chairman of Atlanta Section, A.I. Ch.E. Licensed as Professional Engineer (Chemical) by States of Georgia and Pennsylvania and as Professional Engineer (Metallurgical) by State of California. Consultant to Oak Ridge National Laboratories, U. S. Atomic Energy Commission, Hayes International Corp., and National Institutes of Health (National Cancer Institute).

Current Fields of Interest

Micromeritics (fine particle technology), chemistry and physics of surfaces, biomedical engineering, materials science.

Major Reports and Publications

1. "Deagglomeration of Kaolin by High-Energy, Ionizing Radiation," Reports on Contract AT(38-1)-202, Task 4, 1959-1960, with W.J. Corbett.
2. "Gamma-Irradiation of Kaolinite," Clays and Clay Minerals Vol. X, 344-355, (1963) with others.
3. "Particle Classifier Employing Adhesion Principle," Final Report on Project B-220, Research Grant AP-120(cl), Dept. of Health, Education, and Welfare, 1960-1962, with others.
4. "Aerosol Size Distributions in the Submicron Range from Ion Mobility Measurements," presented at the 1st Annual Conference of the American Association for Contamination Control in San Francisco. Published in the conference proceeding, 1962, with Clyde Orr, Jr.
5. "Centrifugal Separation and Classification," Final Report on Project B-229, Research Grant AP-127(cl), Dept. of Health, Education, and Welfare, 1960-1962, with others.
6. "Particle Size Classifier for the Sub-Sieve Range," The Review of Scientific Instruments 34, No. 9, 1023-1025, (1963), with others.
7. "Residual Stress Determination by X-Ray Diffraction," presented to Southeastern Chapter of the Society for Non-Destructive Testing, May 1963.
8. "Particle Size Classification by Adhesion," Nature 200, No. 4904, 360-361, (1963).
9. "Thermodynamic Aspects of Corrosion," presented to the Southeastern meeting of the National Association of Corrosion Engineers, December 1964.
10. "Particle Motion in Centrifugal Fields," Third Symposium of the Chemical Engineering Society of Japan, 137-142, November 1964, with others.
11. "Particle Trajectories in Centrifugal Force Fields," Final Report on Projects B-248 and B-265, Research Grant OH-00130-01 and 02, Dept. of Health, Education, and Welfare, 1963-1964, with others.
12. "Particle Dynamics in Centrifugal Force Fields," Ph.D. Thesis in Chemical Engineering, 1964.
13. "Study for Improvement of Ground Test, Instrumentation Systems and Methods - New Methods for Stage Propellant Tank Proof Testing," Reports on Contract NAS-8-20110, Project A-855, 1965.
14. "The Role of High Speed Computers in Thermodynamic Calculations," presented to the Southeastern meeting of the American Institute of Chemical Engineers, Daytona Beach, Florida, May 1965 with L.W. Ross.
15. "The Influence of Electrostatic Effects on the Properties of Organic Powders," Reports on Project A-763, Contract DA-AMC-18-035-74A, U.S. Army Chemical Research and Development Laboratories, April 1966.
16. "Particle Size Distribution Measurements of Tungsten Powders," Final Report on Project A-941, Union Carbide Corporation, Nuclear Division, July 1966.
17. "Gas Phase Centrifugal Methods of Particle Size Analysis", presented at the Fine Particle Properties Workshop, Fairleigh-Dickinson University, Madison, New Jersey, July 1966.

Major Reports and Publications (continued)

18. "The Fundamentals of Metal Dusting," Proceedings of the American Petroleum Institute, Section III, 46, 331-334 (1966) with R. F. Hochman.
19. "A New Centrifugal Particle Classifier," published in Public Health Service Reviews (1967).
20. "Liquid Surface Profiles in Contact with Symmetrical Solid Surfaces," Powder Technology, 1, 28-32 (1967), with others.
21. "Electrostatic Properties and Behavior of Selected Powders," presented at Electrostatics Symposium, Fort Detrick, Maryland, April 1967. To be published in Symposium Proceedings.
22. "A Review of Gas Phase Particle Sizing Techniques," presented at the Fine Particle Properties Workshop, Hopatcong, New Jersey, July 1967.
23. "Development of a Gas Centrifuge for Particle Separations," presented at Engineering Foundation Research Conference on Particulate Matter Systems, University School, Milwaukee. Wisconsin, August 1967.
24. "Thermodynamic and Kinetic Analysis of Chemical Vapor Deposition," Proceedings of the Conference on Chemical Vapor Deposition of Refractory Metals, Alloys, and Compounds, p. 57-71, September 1967.
25. "Aerosol Research in Chemical Engineering at Georgia Tech," Air Pollution Control Association Journal, 17, 590-592 (1967), with others.
26. "Particle Size Distribution Measurements," presented at Southeastern Regional Meeting of American Chemical Society, November 1967.
27. "The Influence of Electrostatic Effects on the Dispersion of Organic Powders," Reports on Project A-957, Contract DA 18-035-AMC-1058(A), U.S. Army Edgewood Arsenal Chemical Research and Development Laboratories, March 1968.
28. "Particulate Behavior and Properties," Encyclopedic Dictionary of Physics, Supplement III, 291-294 (1968).
29. "Particle Dynamics in Centrifugal Fields," Powder Technology, 1, 305-315 (1968).
30. "The Influence of Electrostatic Effects on the Dispersion of Organic Powders," Final Report on Project A-957, Contract DA 18-035-AMC-1058(A), Department of the Army, Edgewood Arsenal, August 1968, with others.
31. "Air Cleaning by High-Speed Inertial Impaction," Final Report on Project B-278, Research Grant AP-00373, Department of Health, Education, and Welfare, September 1968, with others.
32. "Industrial Emission Control", workshop sessions jointly sponsored by Georgia Dept. of Public Health and Georgia Tech Industrial Development Divisions. Presentations made at Macon, Albany, Augusta, Savannah, Brunswick, and Rome, Georgia. August 1970 through December 1970.

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

GORTON, CHARLES W.--Professor, School of Chemical Engineering and Division Adviser

Education

B.S.M.E., Louisiana Polytechnic Institute	1950
M.S.M.E., Georgia Institute of Technology	1951
Ph.D.M.E., Purdue University	1953

Employment History

Georgia Institute of Technology, Graduate Assistant	1950-1951
Purdue University, Westinghouse Research Fellow	1951-1952
Purdue University, National Science Fellow	1952-1953
United Aircraft Research Dept., East Hartford, Conn. Research Engineer	1953-1955
Georgia Institute of Technology	
Associate Professor of Mechanical Engineering	1955-1960
Professor of Mechanical Engineering	1960-1965
Professor of Chemical Engineering	1965-Present
Consultant to the Martin Company, Orlando, Florida	1962-1964
Aerospace Sciences Research Lab, The Martin Co., Orlando, Fla. Senior Research Scientist	Summer 1963
Consultant to Oak Ridge National Laboratory	1967-1968

Experience Summary: At United worked in the Thermodynamics Group in the Analysis Section and performed analytical work in combustion, heat transfer, fluid flow, aerodynamic heating, and de-icing. At United also taught undergraduate courses in Thermodynamics and Fluid Mechanics for the Pratt and Whitney Training School. In the Mechanical Engineering Department at Georgia Tech taught undergraduate courses in Heat Transfer, Fluid Mechanics, Thermodynamics, and Combustion, and graduate courses in Thermodynamics, Fluid Mechanics, Mass Transfer and Combustion. While in the Mechanical Engineering Department helped to develop the Ph.D. program and advised many M.S. and Ph.D. theses in Heat Transfer and Fluid Flow, some of which were supported by research grants pertaining to fluid flow and free convection heat transfer. Presently advising Ph.D. theses in the following areas: combustion, pack cementation, and fluid flow. In the Chemical Engineering Department has taught undergraduate courses in Transport Phenomena and graduate courses in Fluid Flow and Heat Transfer. At the Engineering Experiment Station has worked on hydroocyclones, reentry heating, aerodynamic heating for low-altitude supersonic flight, arc-plasma testing, rain erosion, and chemical vapor deposition. At Martin worked on combustion, high velocity flow instrumentation, and heat transfer in dissociated environments.

Current Field of Interest

Transport phenomena including: aerodynamic heating and ablation; combustion including: heterogeneous combustion and combustion in jet mixing regions (at sub and supersonic speeds); rain erosion; chemical vapor deposition; and waste management.

Major Reports and Publications

1. "Preliminary Investigation of the Mestastable Limit of Liquid Water," M.S. Thesis, Georgia Institute of Technology, 1951
2. "Head Transfer Coefficients Between Drops of Liquid and a Hot Plate," Ph.D. Thesis, Purdue University, 1953
3. "Two Confidential Research Memoranda," United Aircraft Research Dept., 1953-1954
4. "An Evaluation of the Hot Air Engine for Helicopter Use," Research Memorandum, United Aircraft Research Dept., 1954
5. "Research Report M-0869-1 concerning anti-icing heating requirements of propeller spinners. United Aircraft Research Dept., 1955
6. "Analytical Solution of a Thermal Entrance Problem," Appendix A, Final Report, Office of Ordnance Research Project No. 1164 on "Wetting Effect on Heat Transfer," 1957
7. "The Mechanical Engineering Approach to Systems Engineering," The Research Engineer, Georgia Institute of Technology (April 1962)
8. "Non-Isothermal Velocity Profiles," A communication to the Editor, A. I. Che. Journal, (January 1963), with others
9. "Transient Response of a Transpiration-Cooled Slab Exposed to a Constant Heat Flux," Presented in Aerospace Forum I at 31st Annual IAS Meeting, January 1963, bound in Fairchild Fund Paper No. FF-34, with others
10. "Research Areas in High Velocity Flow Instrumentation," Martin-Orlando Report OR 3717, January 1964
11. "Viscous Fluid Flow Under the Influence of a Resonant Acoustic Field," A.S.M.E. Journal of Heat Transfer (February 1964), 97-106, with others
12. "The Combustion of Pyrolytic Boron Nitride," Progress in Astronautics and Aeronautics (Vol. XV) AIAA (1964), with others
13. "An Analysis of a Compressible, Turbulent Boundary Layer on a Chemically Reacting Pyrolytic Boron Nitride Surface," AIAA Entry Technology Conference, Williamsburg, Virginia, 12-14 October 1964, with others
14. "Through-Flow Drying of Tufted Textile Materials," Textile Research Journal, 1031-1039 (December 1964), with others
15. "An Analysis of a Compressible Turbulent Boundary Layer on a Chemically-Reacting Pyrolytic Boron-Nitride Surface," Technical Note, AIAA Journal Vol. 3, No. 7, July 1965, pp 1354-1356, (previously presented see item 13 above), with others
16. "Simultaneous Heat, Momentumn and Mass Transfer in the Trough-Flow Drying of Agricultural Products," presented at the Southeast Regional Meeting of the American Society of Agricultural Engineers, Chattanooga, Tenn., February 7, 1966, with others
17. "Design and Development of an Electromagnetic Window for Air Lift Reentry Vehicles," Final Technical Report AFAL-TR-66-34, March 1966, performed under USAF Contract 33(657)-11504, with others
18. "Design/Development of Slip-Cast Fused Silica Nose Cap for Trailblazer III Vehicle," presented at the U. S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia, June 1-3, 1966, with others
19. "A Hydrosonic Rain Erosion Test Program," presented at the U. S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia, June 1-3, 1966, with others

Major Reports and Publications (continued)

20. "A Feasibility Study for an Integrated Radome Antenna (RADANT)," U.S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia, June 1-3, 1966, with others
21. "Ceramic Systems for Missile Structural Applications," Final Summary Report, October 1966, performed under Navy Contract NOw-63-0143-d, Bureau of Naval Weapons, with others
22. "Development of Lightweight Broadband Radomes From Slip-Cast Fused Silica," Final Technical Report AFAL-TR-67-56, April 1967, performed under USAF Contract 33(615)-3445, with others
23. "Filament Wound Silica Radome Techniques," Final Technical Report AFAL-TR-67-65, April 1967, performed under USAF Contract 33 (615)-3330, with others
24. "Ceramic Systems for Missile Structural Applications," Quarterly Reports on Naval Ordnance Systems Command, Contract N00017-67-C-0053, 1967, with others
25. "Rain Erosion of Ceramic at High Mach Numbers," Proceedings of the Second Conference on Rain Erosion, Meersburg, West Germany, August 1967, with others
26. "Rain Erosion at High Mach Numbers," International Conference on Electromagnetic Windows, Paris, France, September 1967, with others
27. "Development in Ablation and Combustion Applicable to Chemical Vapor Deposition," Proceedings of the Conference on Chemical Vapor Deposition of Refractory Metals, Alloys, and Compounds, Gatlinburg, Tennessee, September 1967
28. "Chemical Vapor Deposition Statistical Parametric Study," Proceedings of the Conference on Chemical Vapor Deposition of Refractory Metals, Alloys, and Compounds, Gatlinburg, Tennessee, September 1967, with others
29. "Thermal Tests of Slip-Cast Fused Silica Radomes with Uncooled Attachments," USAF Avionics Laboratory-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia, June 12-14, 1968, with others
30. "Uncooled Attachment Design for Slip-Cast Fused Silica Radomes," Technical Report No. 4 on Contract N00017-67-C-0053, April 1970
31. "Evaluation of Ceramic Coatings for Rain Erosion Protection," Proceedings of the USAF-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia, July 1970, with others

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

HARRIS, JOE NORMAN--Head, Processes and Fabrication Branch, High Temperature Materials Division, Engineering Experiment Station

Education

B.Cer.E., Georgia Institute of Technology 1955

Employment History

Georgia Institute of Technology
- Research Assistant 1955

U.S. Army Chemical Corps, Ft. McClellan, Alabama
- Second Lieutenant 1956

Georgia Institute of Technology
- Research Assistant 1956-1959
- Assistant Research Engineer 1959-1965
- Senior Research Engineer 1965-Present
- Supervisor of Processes and Fabrication Section 1964-1968
- Head, Processes and Fabrication Branch 1968-Present

Experience Summary: Work on ceramic materials includes magnetic iron oxide materials for recording tape, development of slip-cast fused silica for foundry molds nuclear applications and development of lightweight materials for optical uses such as telescope reflectors. Also worked with clay-fiber and ceramic oxide fiber felted systems incorporating both inorganic and organic fibers in structural shapes. Worked with textile techniques for forming ceramic fibers into flexible materials. Directed studies on porcelain enameling quality steel plates for shipboard use and on high temperature electrical insulation for wire. Worked with ceramic techniques to find new uses for granite. Worked with filament winding techniques to increase the apparent strength of slip-cast fused silica. Directed studies on rain erosion resistance of slip-cast fused silica.

Current Fields of Interest

Methods for forming monolithic and composite ceramics and ceramic coatings, continuous and discontinuous fiber applications in ceramic or metal matrices, fabrication equipment design, bench scale, pilot plant and production process design, glass-technology - bulk, fiber and coatings, aerospace and industrial prototype hardware fabrication.

Patents

"Porosity Data Apparatus," U.S. Patent No. 3,309,912 March 21, 1967 with others.

Major Reports and Publications

1. "Research to Determine the Factors Which Affect the Enameling Characteristics of Steel Plate and Weldments for Shipboard Use," Reports under Contract NObs-72209 and NObs-77022, Bureau of Ships, 1957-1960, with others
2. "High Temperature Insulation for Wire," Reports under WADC Contract AF 33(616)-3944 (WADC TR 58-13, Parts II and III), 1957-1960, with others

Major Reports and Publications (Continued)

3. "Porcelain Enameled Steel Plate," Research Engineer 12, No. 4, 10-12, (October 1957)
4. "High Temperature Electrical Insulation," Research Engineer 12, No. 4 13-14 (October 1957)
5. "A Flexible High Temperature Wire Insulation," presented at the 60th Annual Meeting of the American Ceramic Society, Pittsburgh, Pennsylvania, 27-30 April 1958
6. "High Temperature Electrical Insulation," Research Engineer 13, No. 5, 14-15 (December 1958)
7. "Porcelain Enameled Steel Plate," Research Engineer 13, No. 5, 16-17, (December 1958)
8. "Ceramics for High Temperature Electrical Applications," presented at the Second National Conference on the Applications of Electrical Insulation, Washington, D. C., 8-11 December 1959
9. "A Successful Study of Steel, Porcelain and Fishscale," Research Engineer 15, No. 1, 22-24 (February 1960)
10. "For Electrical Insulation: A Flexible Ceramic," Research Engineer 15, No. 1, 24-26 (February 1960)
11. "Effects of Irradiation on the Strength of Slip-Cast Fused Silica," presented at the Summer Meeting of the Southeastern Section of the American Ceramic Society, Gatlinburg, Tennessee, 15-17 June 1961
12. "Porosity Measurements by Air Displacement," Materials Research and Standards, ASTM 3, 20-24 (January 1963), with others
13. "Ceramic Systems for Missile Structural Applications," Reports on Contract NOw-63-0143-d, 1963, with others
14. "Design and Development of an EM Window for Air Lift Reentry Vehicles," AFAL TR-65-86 May 1965
15. "A Program of Research and Technical Assistance for the Granite Industry in Elbert County, Georgia," Reports on Contract Cc-6033, U. S. Department of Commerce, 1963-1965, with others
16. "Felted Ceramics and Pre-Stressed Slip-Cast Fused Silica," presented at the Tenth Refractory Composites Working Group Meeting, Atlanta, Georgia, April 1965
17. "Fibrous Ceramic Structures," American Ceramic Society Bulletin 45 1075-1077 No. 12, Dec. 1966
18. "Rain Erosion Sled Testing of Slip-Cast Fused Silica Radomes," Final Report, Contract DA-01-021-AMC-14464(Z), March 1967
19. "Filament Wound Silica Radome Techniques," AFAL-TR-67-65 April 1967
20. "High Strength, Broadband, Lightweight Silicon Oxide Radome Techniques," AFAL-TR-68-71 April 1968
21. "High Strength, Broadband, Lightweight Silicon Oxide Radome Techniques," AFAL-TR-69-103 April 1969

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

KENG, EDWARD Y.H.--Senior Research Engineer, Engineering Experiment Station

Education

B.S. in Ch.E., Tunghai University	1959
M.S. in Ch.E., Georgia Institute of Technology	1964

Employment History

Rice University, Research Assistant	1961-1962
Georgia Institute of Technology	
Engineering Experiment Station	
Graduate Research Assistant	1962-1966
Research Engineer	1966-1970
Senior Research Engineer	1970 - Present

Experience Summary: Began career by working on investigations into the solubilities of gases in liquids, photophoretic behavior of particulates in atmosphere, and particle size classification. Since 1964 has conducted and directed investigations into the dispersion and generation of aerosols, radiant heat transfer to particle-seeded gases, liquid atomization, thermal force on particulates, electrostatic effects on dispersed particles, coagulation of airborne particles, formation of particulates from gaseous impurities in air under the influence of radiation, condensation and nucleation phenomena of hygroscopic particulates, aerosol sampling and particulate size determination. Also engaged in the development of contrifugal classifiers, aerosol generators, and gas pycnometer. Member, American Institute of Chemical Engineers, American Chemical Society, Fine Particle Society, and Society of Sigma Xi.

Current Fields of Interest

Particulate technology; air pollution; radiant heat transfer.

Patents

1. "Method and apparatus for Volume Measurement" U.S. Patent No. 3,453,881 (1969); British Patent No. 1,220,313 (1971).

Major Reports and Publications

1. "An Experimental Study of the Solubilities of Nitrous Oxide in Normal Heptane and Normal Dodecane," Report prepared for Scott Corporation, Rice University, 1962, with R. Kobayashi.
2. "Photophoresis as Related to Meteorological Phenomena," Final Report on Project B-222, Contract No. G-19273, National Science Foundation, 1963, with C. Orr, Jr.
3. "Light Boundary Effect in Photophoresis," Nature 200, 352, 1963, with C. Orr, Jr.

Major Reports and Publications (continued)

4. "Particle Trajectories in a Centrifugal Classifier," Final Report on Projects B-248 and B-265, Research Grant OH-00130-01 and 02, Dept. of Health, Education, and Welfare, 1964, with others.
5. "An Investigation on Photophoresis," M.S. Thesis in Chemical Engineering, 1964.
6. "Heat Transfer to a Gas Containing a Cloud of Particles," Special Report on Project A-635-002, Research Grant NsG-273-62, National Aeronautics and Space Administration, 1962-1965, with others.
7. "Photophoresis in Stratosphere," Journal of the Atmospheric Science,21, No. 5 475-78, 1964, with C. Orr, Jr.
8. "Heat Transfer to a Gas Containing a Cloud of Particles," NASA CR-54441, Nuclear Reactor Division, NASA Lewis Research Center, Cleveland, Ohio, July 1965, with others.
9. "Heat Transfer to a Gas Containing a Cloud of Particles," NASA CR-325, National Aeronautics and Space Administration, Washington, D.C., November 1965, with others.
10. "Thermal Precipitation and Particle Conductivity," Journal of Colloid and Interface Science,22, 107-16, 1966, with C. Orr, Jr.
11. "A Study of Vibrating-Capillary Atomizers," Final Report on Project B-279, Research Grant AP-00351, Dept. of Health, Education, and Welfare, 1967, with others.
12. "Aerosol Research in Chemical Engineering at Georgia Tech," Air Pollution Control Association Journal,17, 590-2, September 1967, with others.
13. "Investigation of Radiant Heat Transfer to Particle-Seeded Gases for Application to Nuclear Rocket Engine Design," NASA CR-953, National Aeronautics and Space Administration, Washington, D.C., 1967, with C. Orr, Jr.
14. "Particle Dynamics in Centrifugal Fields," Powder Technology,1, No. 5, 305-15, 1968, with others.
15. "Particle Size and the Rate of Radiant Heat Transfer to Gas-Suspended Particles," Powder Technology,1, No. 6, 323-7, 1968, with C. Orr, Jr.
16. "The Influence of Electrostatic Effects on the Dispersion of Organic Powders," Final Report on Project A-957, Contract DA 18-035-AMC-1058 (A), U.S. Army Edgewood Arsenal Chemical Research and Development Laboratories, August 1968, with others.
17. "Characteristics of Atmospheric Hygroscopic Particulates under Changing Humidity Conditions," presented at 156th ACS National Meeting, Atlantic City, New Jersey, September 1968.
18. "Heat Transfer to a Gas Containing a Cloud of Particles," Final Report on Project A-635, Research Grant NsG-273-62, National Aeronautics and Space Administration, January 1969, with C. Orr, Jr.
19. "Hysteresis in Smog and Fog Disappearance," Final Report on Project B-330, Contract AP-00345, Dept. of Health, Education and Welfare, February 1969, with others.
20. "Growth of Hygroscopic Particles in Polluted Air," presented at 1969 AIChE Ga.-Fla. Joint Meeting, Daytona Beach, Florida, May 1969.
21. "Air and Helium Pycnometer" Powder Technology, 3, No. 3, 179-180, 1969.

Major Reports and Publications (continued)

22. "Application of Zoning Techniques in Practical Radiative Energy Transport Problems", Proceedings of a Symposium on Research on Uranium Plasmas and Their Technological Applications, Gainesville, Florida, January 7-9, 1970.
23. "Gaseous Impurities and Nuclear Condensation on Airborne Sodium Chloride Particles," Environmental Science and Technology, 4, No. 5, 417-420 (1970).
24. "Coagulation Behavior of Typical Industrial Aerosols," presented at 1970 AIChE Ga. - Fla. Joint Meeting, Daytona Beach, Florida, May 1970.
25. "Radiant Heat Transfer to Absorbing Fluid Media", Journal of Chemical Engineering of Japan, 3, No. 2, 171-6 (1970) with C. Orr, Jr.
26. "Sampling and Particulate Size Determination", Chapter V, Handbook on Aerosols, in preparation.
27. "Particle Handling and Transport," Chapter V, Fine Particle Technology, in preparation.
28. "Aerosols Produced by X-Rays," accepted for publication in the Journal of Colloid and Interface Science.

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

MATTESON, MICHAEL J. -- Assistant Professor of Chemical Engineering

Education

B. S. in Ch. E., University of Washington, 1958
M. S. in Ch. E., University of Washington, 1960
Doctor of Engineering in Ch. E., Technical University Clausthal, Germany 1967

Employment History

Puget Sound Pulp and Paper Company, Bellingham, Washington, Chemical Engineer, 1956-1957.

Boeing Airplane Company, Seattle, Washington, Aerospace Research Engineer, 1963-1964.

Experience Summary: Graduate student in the Department of Chemical Engineering, University of Washington from September, 1958 to March, 1960. Completed M.S. thesis which dealt with the design of a Venturi Scrubber for dust removal systems. Research Assistantship involved the construction of a pilot plant for the reclamation of Kraft Pulp Mill effluents. Continued as a Research Engineer, Air Resources Engineering, Sanitary Engineering Division, Department of Civil Engineering at the University of Washington from November, 1963 to December, 1964, where primary duties included assisting in studies on effects of aerosols on visibility. Studied at the Max-Planck-Institute for Experimental Medicine, Gottingen, and the Technical University Clausthal, Germany, from January, 1965 to November, 1967, where doctoral research was completed on the reaction between SO_2 in polluted atmospheres and aerosols containing $MnSO_4$. Post-doctoral research conducted at the University of Rochester, Rochester, New York, from November, 1967 to September, 1969, on U.S.P.H.S. Air Pollution Special Fellowship. Research entailed study of surface electrical aspects of wet aerosols. Presently, is Assistant Professor in the School of Chemical Engineering, Georgia Tech; Co-director, Environmental Protection Agency Training Grant: "Georgia Tech Air Quality Control Training Program"; teacher-courses in Industrial Emissions Control, Aerosol Technology, Atmospheric Chemical Reactions; Principal Investigator, NSF Research Award: "Application of High Voltage Electrical Fields to the Removal of SO_2 and NO_2 from Combustion Effluents." Member, Air Pollution Control Association, Southern Section, Executive Board; American Institute of Chemical Engineers, Vice Chairman, Atlanta Section; Fine Particle Society; American Chemical Society; Technical Advisory Committee, Atlanta Citizens Coalition for Clean Air; and Sigma Xi Honorary.

Major Reports and Publications

"Momentum Exchange in a Venturi Scrubber," M.S. Thesis, University of Washington, 1960.

"Uber die Reaktion zwischen gasformigem schwefeldioxid und Mangansulfat-Aerosolen," Doctoral Dissertation in ChE, Technical University Clausthal, Germany, 1967.

"The Kinetics of the Catalytic Oxidation of SO_2 by Aqueous Aerosols of $MnSO_4$," Ind. and Eng. Chem. Fundamentals, 8, No. 4, 677-687, November (1969), with W. Stober and H. Luther.

"The Generation of Aerosols from Various Electrolyte Solutions," Journal of Colloid Sci. 23, 203-214, (1967), with W. Stober.

"A Pilot Plant for the Steam-Stripping of Kraft Pulp Mill Effluents," TAPPI, 50, 86-91, (1967), with L. N. Johanson and J. L. McCarthy.

"Analytical Applications of Filtration," Chapter XII, 400 pp. Book, Filtration--Principles and Techniques, Marcel Dekker, Inc., New York, in preparation.

"The Separation of Charge at the Gas-Liquid Interface by Dispersion of Various Electrolyte Solutions," A.C.S. 45th National Colloid Symposium, June, 1971. Accepted for publication, Journal of Colloid and Interfacial Science.

"Aerosol Size Determination in the Submicron Region by Thermophoresis," accepted for publication, Journal of Aerosol Science.

"Sulfur Oxide Control," Chapter 6, Volume II, Environmental Engineers' Handbook, Air Pollution, Chilton Book Company, Philadelphia, in preparation.

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

MERRITT, ALLEN C.--Ph.D. Candidate, School of Chemical Engineering and Assistant Research Engineer

Education

B.Ch.E., Georgia Institute of Technology	1968
M.S.Ch.E., Georgia Institute of Technology	1969
Ph.D.Ch.E., Georgia Institute of Technology	Present
M.S.I.M., Georgia Institute of Technology	Present

Employment History:

Proctor & Gamble Co., Summer Engineer	Summer 1966
Georgia Institute of Technology, Student Assistant	Winter-Spring 1967
Proctor & Gamble Co., Summer Engineer	Summer 1967
Georgia Institute of Technology	
Student Assistant	1967-1968
Graduate Student Assistant	1968-1969
Continental Oil Fellowship	1968-1969
Assistant Research Engineer	1969-1970
U.S. Army Air Defense Artillary	1968-1970
Georgia Institute of Technology, Assistant Research Engineer	1970-Present

Experience Summary: At Proctor & Gamble Company worked in production management as manager of the Bulk Shortning and Refrigeration Department the first summer. The second summer was assigned to the Math, Computing and Special Equipment Group of the Engineering Division there wrote computer programs to analyse multistage distillation columns operation; to design multistage condensor units, to perform normal service functions. While in the School of Chemical Engineering designed and built laboratory equipment and instructed laboratory experiments in transport phenomena. While at the High Temperature Materials Division of the Engineering Experiment Station have worked on projects dealing with chemical vapor deposition and pack cementation of surface and diffusion coatings, have worked on projects and designed computer analysis programs dealing with transient high temperature thermal analysis of materials, have worked on projects dealing with the production of ferrite materials utilizing inovative techniques and have worked on projects dealing with material properties and response to rain erosion, dust erosion, and chemical strengthening. Have participated in pollution research and the Air Quality Control Program at Georgia Tech.

Current Fields of Interest

Transport Phenomena including Reacting Flow Systems and computer analysis of problem simulation. Air Quality Control with specialty in odor abatement.

Major Reports & Publications

1. "Manufacturing Techniques for Ferrites and Garnets used in Phased Array Radar "U"," Second Quarterly Progress Report IE-TR-69, January 1970, with others
2. "Manufacturing Techniques for Ferrites and Garnets used in Phased Array Radar "U"," Fifth Quarterly Progress Report IE-TR-70, October 1970, with others
3. "Densification of Slip-Cast Fused Silica," Paper presented at the 1971 American Ceramic Society Meeting, Chicago, Illinois, April 24-29, 1970, with others

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

ORR, CLYDE, JR. -- Head of Micromeritics Branch, Engineering and Experiment Station, and Regents' Professor of Chemical Engineering

Education

B. S. in Ch.E., University of Tennessee	1944
M. S. in Ch.E., University of Tennessee	1948
Ph.D. in Ch.E., Georgia Institute of Technology	1953

Employment History

U. S. Navy, CIC Officer	1944-1946
TVA, Wilson Dam, Alabama, Chemical Engineer	1946-1947
Georgia Institute of Technology	
Research Engineer	1948-1952
Research Assistant Professor	1952-1953
Research Associate Professor	1953-1958
Research Professor of Chemical Engineering	1958-1962
Professor of Chemical Engineering	1962-1966
Regents' Professor of Chemical Engineering	1966-Present

Experience Summary: Began career with process development for phosphoric acid production, but in research at Georgia Tech shifted largely into micromeritics (fine particle technology). Since 1949 has conducted and directed investigations into the chemical engineering and physical chemistry of a wide variety of types of finely divided materials, including colloidal systems, aerosols, and powders in mass. Work has led from scientific studies with bacteria into natural cloud phenomena and into the basic properties exhibited by matter--such as surface energy, nucleation ability, radiation responses, inhalation effects, and the behavior of particles in space. Engineering interests center around unit operations that involve particulate matter, e.g., atomization, grinding, fluidization, filtration, pneumatic conveying, and the like. Graduate courses in micromeritics taught in the School of Chemical Engineering; undergraduate course teaching includes heat transfer, comprehensive problems, and process control. Listed in World Who's Who in Science, Who's Who in the South and Southwest, The Authors and Writer's Who's Who, Who's Who in Engineering, American Men of Science, Dictionary of International Biography, and The Directory of British and American Writers. Director, American Association for Contamination Control (1961-63). Consultant at various times to Oak Ridge National Laboratory, Xerox Corp., Allen-Bradley Co., Rohm and Haas Co., Technical Operations Research, National Air Pollution Control Administration of USPHS, and others. Member, A.I.Ch.E., ACS.

Current Fields of Interest

Micromeritics (fine particle technology); atmospheric phenomena; instrumentation.

ORR, CLYDE, JR. Biographical Sketch

Major Reports and Publications

1. "A Study of the Sulphur Dioxide, Sulphur Trioxide, Chlorides, Acid, and Dust in the Air in the Vicinity of Bush Field near Augusta, Ga.," Prepared for the Chamber of Commerce, August, Ga., March 1949, with J. M. DallaValle.
2. "Research on Surface Properties of Fine Particles," 8 reports on Contract W 36-039 SC-38258, 1949-1951, with J. M. DallaValle and others.
3. "Investigation of Aggregation of Fine Particle Matter Suspended in Air," 4 reports on Contract DA 18-064-CML-402, 1950-1951, with J. M. DallaValle with others.
4. "Fine Particles," Scientific American 183, 50-53 (1950).
5. "Limitations of the Arealometer Method for the Measurement of Fiber Diameters," Textile Research Journal 20, 676-82 (1950) with J. M. DallaValle and others.
6. "Fitting Bimodal Particle Size Distribution Curves," Ind. Eng. Chem. 43, 1377-80 (1951), with J. M. DallaValle and others.
7. "Research on Surface Properties of Fine Particles," 8 reports on Contract DA 36-039 SC-5411, 1951-1953, with J. M. DallaValle and others.
8. "Investigation of Aggregation of Fine Particle Matter Suspended in Air," 8 reports on Contract DA 18-064 CML-490, 1951-1953, with J. M. DallaValle and others.
9. "A Rapid Liquid-Phase Adsorption Method for the Determination of the Surface Area of Clays," J. Am. Cer. Society 56, 58-60 (1952), with others.
10. "A Thermal Precipitator for Aerobacteriology," Science 116, 368 (1952), with T. W. Kethley and M. T. Gordon.
11. "Surface Areas of Metals and Metal Compounds: A Rapid Method of Determination," J. of Metals 4, 657-60 (1952), with others.
12. "Settling of Particles in a Thermal Gradient," Proceedings of the Third Midwestern Conference on Fluid Mechanics, 741-57, 1953, with J. M. DallaValle and H. G. Blocker.
13. "Dynamic Gas Adsorption Methods of Surface Area Determination," J. Phys. Chem. 57, 517-20 (1953), with others.
14. "The Aggregation of Aerosols," Report of Symposium V--Aerosols, Army Chemical Center, Md., June 1953, with J. M. DallaValle.
15. "Standardization of Surface Properties of Fine Particles," 4 reports on Contract DA 36-039 SC-42588, 1953-1954, with J. M. DallaValle and H. G. Blocker.
16. "An Investigation of Factors Determining Aggregation of Fine Particle Matter," 4 reports Contract DA 18-064 CML-2379, 1953-1954, with others.
17. "Heat-Transfer Properties of Liquid-Solid Suspensions," Heat-Transfer-Research Studies for 1954, Chemical Engineering Progress Symposium Series, No. 9, Vol. 50, 29-45, 1954, with J. M. DallaValle.
18. "Thermal Precipitation in Air Pollution Studies," J. of Air Pollution Control Association 4, 1, 1-4 (1954), with M. T. Gordon.
19. "A New Method for the Measurement of Aerosol Electrification," J. Colloid Sci. 9, 70-80 (1954), with B. L. Hinkle and others.
20. "The Aggregation of Aerosols," Brit. J. Appl. Physics, Supplement No. 3, 198-206 (1954), with J. M. DallaValle and others.

Major Reports and Publications (continued)

21. "Investigations of the Relation, If Any, Between Viability and Electric Charges on Airborne Micro-organisms or Particles Containing Such Micro-organisms," 4 Reports on Contract DA 18-064 CML-2570, 1954, with others.
22. "An Investigation into the Growth of Small Aerosol Particles with Humidity Change," 8 Reports on Contract AF 19(604)-1086, 1954-1956, with others.
23. "Thermal Conductivity of Granulated Beds," Ind. Eng. Chem. 47, 356 (1955).
24. "The Viscosity of Suspension of Spheres," J. of Colloid Science 10, 24-8 (1955) with H.G. Blocker.
25. "Studies and Investigations of Agglomeration and Deagglomeration," 20 Reports on Contract DA 18-064-404 DML-88, 1955-1957, with J.M. DallaValle.
26. "The Density and Size of Airborne Serratia marcescens Cells," J. Bacteriology 71, 315-17 (1956) with M.T. Gordon.
27. "Thermal Precipitation for Sampling Airborne Micro-organisms," J. Appl. Microbiology 4,116-18 (1956), with M.T. Gordon and Margaret C. Kordecki.
28. "A Continuous Thermal Precipitator for Aerosol Sampling," Final Report on Grant from University Center in Georgia, 1956.
29. "Aerosol Studies at Georgia Tech," Research Engineer 12, 2, 15-19 (April 1957).
30. "Airborne Micro-organisms as Analytical Tools in Aerosol Studies," J. of the Air Pollution Control Assoc. 7, 16-20 (1957), with T.W. Kethley, E.L. Fincher and J.M. DallaValle.
31. "The Behavior of Condensation Nuclei Under Changing Humidities," J. of Meteorology 15, 240-2 (1958), with F.K. Hurd, W.P. Hendrix, and C. Junge.
32. FINE PARTICLE MEASUREMENT, The Macmillan Company, New York, N.Y., 1959 with J. M. DallaValle.
33. "Aerosol Size and Relative Humidity," J. Colloid Sci. 13, 472-82 (1958) with F.K. Hurd and W.J. Corbett.
34. "A Thermal Precipitator for Continuous Aerosol Sampling," The Review of Scientific Instruments 28, 129-30 (1958), with R.A. Martin.
35. "A Study of Equilibria Involved Between Darex Off-Gases and Solutions," 8 Reports on Subcontract 1373 under W-7405-ENG-26, 1958-1959, with others.
36. "A Study of the Solubility and Rate of Solution of Fine Aerosol Particles," 8 Reports on Contract AF 19(604)-1970, 1958-1959, with others.
37. "An Investigation of Thermal Force with Particular Reference to Materials of High Thermal Conductivity," Annual Report on NSF Grant G7051, 1960, with others.
38. "An Investigation of Two-Phase Thermal Conductivity," 8 Reports on Contract DA 91-009 ORD-704, 1958-1960, with others.
39. "Surface Energy of Smog and Fog Nuclei," Annual Report on NIH Grant S-79, 1958-1960, with William J. Corbett.

Major Reports and Publications (continued)

40. BETWEEN EARTH AND SPACE, The Macmillan Company, New York, N. Y., 1959.
41. "Tremendous Power of Lightning," Science Digest 45, 6, 27-32 (1959).
42. "Spectacles in the Skies," Science Digest 46, 2, 76-81 (1959).
43. "Adhesion Between Solid Particles and Solid Surfaces," Final Report on NIH Grant S-87, 1959, with others.
44. "Kaolin Dust Exposure Effects in Production Processing," Preliminary Report on NIH Grant RG-5931, 1969, with L. M. Petrie and R. L. McLean.
45. "A Study of the Alteration of Water Droplet Supercooling by Foreign Vapors," 7 reports on Contract AF 19(604)-4970, 1959-1960 with others.
46. "An Investigation of the Particle—Collecting Capability of Thermal Precipitation at Simulated High-Altitude Conditions," Annual Report on Contract AT(40-1)-2568, 1959-1960, with others.
47. "Source Control by Filtration," Chapter 29 in AIR POLLUTION, Volume II, Academic Press, 1961, with J. M. DallaValle (Arthur C. Stern, editor).
48. "Aerosols" and "Electrostatic Precipitation," sections in ENCYCLOPAEDIC DICTIONARY OF PHYSICS, Volumes 1 and 2, respectively, Pergamon Press, 1961.
49. "Interaction of Submicron Smog Particles and Vapors," Annual and Final Reports on NIH Grant S-106, 1960-1962, with others.
50. "Adhesion of Solid Particles to Solid Surfaces," Archives of Environmental Health 1, 1-9 (1960), with Margaret C. Kordecki.
51. "Our Changing Environment," Landscape, Spring Issue, 28-33 (1960).
52. "The Apparent Viscosity of Gas-Solid Fluidized Systems," J. of Chem. & Engr. Data 5, 430-432 (1960), with F. Liu.
53. Russian, French, Italian, and Indian language editions of BETWEEN EARTH AND SPACE.
54. "Aqua Regia Off-Gases by Infrared Spectrophotometry," Applied Spectroscopy 15, 180-181 (1961), with Margaret C. Kordecki.
55. "An Investigation of Thermal Force with Particular Reference to Materials of High Thermal Conductivity," Final Report on NSF Grant G7051, 1961, with others.
56. "Pigment Particle Size Separation," 5 reports on NASA Contract No. NAS8-848, 1961-62, with others.
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61. "Effects of High Density Ionizing Radiation on Colloidal Systems and Suspensions," 18 reports on AEC Contract No. AT(38-1)-202, 1962-1963, with others.
62. "Hydrogenation of Pulverized Coal in a Plasma Jet," Final Report on Dept. of Interior Contract No. 14-01-001-228, 1962-1963, with others.
63. "Heat Transfer to a Gas Containing a Cloud of Particles," 2 reports on NASA Grant NsG-273-62, 1962-1963, with others.
64. "Photophoresis as Related to Meteorological Phenomena," 2 reports on NSF Grant No. G-19273, 1962-1963, with others.
65. "Particulate Size Analyzer Using Ion Counter Principle," Annual Report on NIH Grant No. OH-00129-02, 1963, with F. K. Hurd and W. P. Hendrix.

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68. "Particle Size Classifier for the Subsieve Range," Rev. Sci. Inst. 34, 1023-1025 (1963), with others.
69. "Particle Size Classification by Adhesion," Nature 200, No. 4904, 360-361 (1963).
70. "Light Boundary Effect in Photophoresis," Nature 200, No. 4904, 352 (1963).
71. "Thermal Conductivities of Aluminum and Zinc Powder Suspensions," J. Chem. & Eng. Data 9, No. 1, 71-74 (1964).
72. "The Photophoretic Force," J. Colloid Sci. 19, No. 1, 50-60 (1964).
73. "Thermal Precipitation at Reduced Gas Pressures," J. Colloid Sci. 19, 571-577 (1964).
74. "Photophoretic Effects in the Stratosphere," J. Atmospheric Sciences 21, No. 5, 475-478 (1964).
75. "Thermal Precipitator," Rev. Scientific Instruments 35, No. 10, 1373-1374 (1964).
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78. Pigment Particle Size Separation, National Aeronautics and Space Administration Report, CR-78, July 1964, with W. J. Corbett.
79. Heat Transfer to a Gas Containing a Cloud of Particles, National Aeronautics and Space Administration Report, CR-54441, July 1965, with J. A. McAlister, E. Y.H. Keng.
80. Heat Transfer to a Gas Containing a Cloud of Particles, National Aeronautics and Space Administration Report, CR-325, November 1965, with J. A. McAlister, E. Y.H. Keng.
81. "Specific Surface Area by Low-Pressure Permeametry," Analytical Chem. 39, 834-6 (1967).
82. "Particle Dynamics in Centrifugal Fields," Powder Technology 1, 305-316 (1968) with others.
83. "A Method for Predicting the Properties of Supersaturated Solutions of the Alkali Chlorides," J. Chem. & Eng. Data 13, 49-53 (1968) with A. F. Hidalgo.
84. "Aerosol Research in Chemical Engineering at Georgia Tech," Air Pollution Control Association Journal 17, 590-592, Sept. 1967, with others.
85. Investigation of Radiant Heat Transfer to Particle-Seeded Gases for Application to Nuclear Rocket Engine Design, CR-953, Washington, D.C., November 1967, with E. Y.H. Keng.
86. "Homogeneous Nucleation of Sodium Chloride Solutions," Industrial and Engineering Chemistry Fundamentals Quarterly 7, 79-83 (1968) with A. F. Hidalgo.
87. "Particle Size and the Rate of Radiant Heat Transfer to Gas-Suspended Particles," Powder Technology 1, 323-327 (1968).
88. "Source Control by Filtration," Chapter 44, in AIR POLLUTION, Volume III (Arthur C. Stern, editor), Academic Press, New York, 1968, with K. Iinoya.

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89. The Influence of Electrostatic Effects on the Dispersion of Organic Powders, Final Report, Contract DA 18-035-AMC-1058(A), U. S. Army Edgewood Arsenal Chemical Research and Development Laboratories, August 1968, with others.
90. "Size Reduction", Encyclopedia of Chemical Technology, Vol. 18, pp. 324-65, John Wiley & Sons, Inc., New York, 1969.
91. "Radiant Heat Transfer to Absorbing Fluid Media", J. Chem. Eng. Japan 3, 171-6 (1970) with E.Y.H. Keng.
92. "Surface Area Measurement" to be published in Treatise on Analytical Chemistry, Interscience Publishers, New York.
93. "Particle Size Measurement" to be published in Treatise on Analytical Chemistry, Interscience Publishers, New York.
94. "Pore Volume Measurement" to be published in Treatise on Analytical Chemistry, Interscience Publishers, New York.
95. FILTRATION--PRINCIPLES AND PRACTICES, as editor, to be published by Marcel Dekker, Inc., New York.
96. "Automatic Sedimentation Size Analysis Instrument" to be published in Proceedings of the Second Particle Size Analysis Conference, Society for Analytical Chemistry, London with W. P. Hendrix.

Patents

1. "Electrical Resistance Paint Capable of Forming a Heating Film," U.S. Patent No. 2,883,307 (1959).
2. "Method and Apparatus for Measuring Electrical Charge on Aerosol Particles," U. S. Patent No. 2,909,960 (1959), with others.
3. "Cascade Impactor for Sampling Smokes, Dusts and Fume," U. S. Patent No. 2,947,164 (1960).
4. "Continuous Thermal Precipitator," U. S. Patent No. 2,947,382 (1960).
5. "Method and Apparatus for Obtaining Data for Determining Surface Area and Pore Volume," U. S. Patent No. 3,262,319 (1966).
6. "Specimen Mounting Device for Porosity Determination Apparatus," U. S. Patent No. 3,348,395 (1967).
7. "Pressure Gauge," U. S. Patent No. 3,368,407 (1968).
8. "Continuous Thermal Precipitator," U. S. Patent No. 3,458,974 (1969).
9. "Method and Apparatus for Measuring Angle of Contact between Liquids and Solids", U. S. Patent No. 3,525,255 (1970).

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

POULOS, NICK E., -- Associate Chief, High Temperature Materials Division, Engineering Experiment Station

Education

B.Cer.E., Georgia Institute of Technology	1952
M.S. in Cer.E., Georgia Institute of Technology	1953
LL.B., Woodrow Wilson Law School	1955

Employment History

U.S. Army Air Force, Flight Engineer	1943-1946
The Coca-Cola Company, Student Engineer	1951-1952
Georgia Institute of Technology	
Research Assistant and Assistant Research Engineer	1953-1957
Research Engineer	1957-1965
Senior Research Engineer	1965-1966
Principal Research Engineer	1966-Present
Associate Chief, High Temperature Materials Division	1968-Present

Experience Summary: Active in ceramic research since 1953. Worked in the design and development of glass containers for increased service life. Director of numerous research projects on clay minerals, high temperature resistant materials and coatings. Research on clay minerals included paper coating clays and clays in refractories. The high temperature resistant materials research included the study of thermite reactions for forming cermets, development of slip-cast fused silica for use as heat treating forming dies and fixtures, radomes, permanent foundry molds, and thermal protection of reentry bodies. Coating research work was with arc-plasma-jet and flame sprayed coatings. Directed work on ceramic and ceramic-metal systems. Also directed studies on inorganic fiber felted systems and their application as high temperature resistant structures. General Coordinator, U. S. Air Force/Georgia Tech Symposium on Electromagnetic Windows, 1966 and in 1968, and General Coordinator, Tenth Symposium on Electromagnetic Windows, July 1970.

Current Fields of Interest

High-temperature resistant materials; ceramic-metal systems; thermal insulative materials for hypervelocity vehicles; new ceramic processes and products development; and R&D management.

Major Reports and Publications

1. "A Method for Studying the Resistance of Enamels to Abrasion by Rapidly Moving Particles Suspended in High-Temperature Flames," American Ceramic Society Bulletin (October 1952)
2. "An Automatic Device for Electrodialysis," presented at the 58th Annual Meeting of the American Ceramic Society, Cincinnati, Ohio, 1955
3. "The Study and Development of New High-Temperature Materials and Coatings," Reports on Contract NOrd 15701, 1956-1962, with others
4. Development of Monolithic Ceramics and Heterogeneous Ceramic-Metal Bodies for Aerodynamic Applications at High Velocities and Temperatures," Reports on Contract DA 01-009 ORD-548, 1957-1959, Contract DA 01-009 ORD-777, 1959-1960, and Contract NAS-8, 1960, with others
5. "Clay Mineral Research," Research Engineer 13, No. 5, 9 (December 1958)
6. "Ceramic Nose Cones," Research Engineer 13, No. 5, 10-11 (December 1958)
7. "Cermets from Thermite Reactions," Journal of the American Ceramic Society 42, 40-49 (1959) with others
8. "The Relationship of Structure of Georgia Kaolin to its Viscosity," Bulletin 23, Engineering Experiment Station, Georgia Institute of Technology, 1959
9. "Fused Silica: The Cinderella Ceramic," Research Engineer 15, No. 1, 7-9 (February 1960)
10. "Man-Made Meteor-The Nose Cone," Research Engineer 15, No. 1, 15,16, (February 1960)
11. "Ceramic Tooling," Research Engineer 15, No. 1, 20-21 (February 1960)
12. "The Use of Thermite Reactions to Produce Refractory Cermets," Ceramic Age 75, 39-45 (1960), with others
13. "Ceramic Tooling and Honeycomb Brazing Fixtures for Supersonic Aircraft Production," American Ceramic Society Bulletin 39, No. 12, 740-742, 747-748 (December 1960)
14. "Fused Silica Refractories," 8th International Ceramic Congress, Det Berlingske Bogtrykkery A/S, Copenhagen, Denmark, 213-222, May 1962, with others
15. "Slip-Cast Metal Fiber Reinforced Ceramics," American Ceramic Society Bulletin 41, No. 11, 778-780 (November 1962), with others
16. "Fused Silica-Hydrated Cements for Thermal Protection Systems," American Ceramic Society Bulletin 41, No. 12, 812-815 (December 1962), with others
17. "Ceramic Systems for Missile Structural Applications," Reports on Contract NOw-63-0143-d, 1962-1966, with others
18. "Design and Development of an EM Window for Air Lift Reentry Vehicles," Reports on Contract No. AF 33(657)-11504, 1963-1966, with others
19. "Spray-On Refractory Coatings System Considerations," presented at the National AIME Meeting, Pyro-Metallurgical Program, Dallas, Texas, February 1963, with others
20. "Slip-Cast Fused Silica," Special Report No. 43, Published in 1964 by Engineering Experiment Station, Georgia Institute of Technology, with others

Major Reports and Publications (continued)

21. "Slip Casting Large Fused Silica Radomes," Proceedings of the OSU-RTD Symposium on Electromagnetic Windows (Vol. III) Session V, Paper D, 2-4 June 1964, with others
22. "Fused Silica for Reentry Radomes," Proceedings of the OSU-RTD Symposium on Electromagnetic Windows (Vol. III) Session VI, Paper B, 2-4 June 1964, with others
23. "Design and Development of an Electromagnetic Window for Air Lift Reentry Vehicles," Technical Report AFAL-TR-65-86, May 1965, with others
24. "Fibrous Ceramic Structures," presented at American Ceramic Society Symposium on "High Temperature Fibers and Fibrous Composites," Philadelphia, Pennsylvania, May 1965, with others
25. "Design and Development of an Electromagnetic Window for Air Lift Reentry Vehicles," Technical Report AFAL-TR-66-34, March 1966, with others
26. "Design/Development of Slip-Cast Fused Silica Nose Cap for Trailblazer III Vehicle," Proceedings of the U.S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Session I, 1-3 June 1966, with others
27. "Thermal Testing of Slip-Cast Fused Silica Radomes," Proceedings of the U.S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Session VI, 1-3 June 1966, with others
28. "A Feasibility Study on the Fabrication of Integrated Radome Antennas," Proceedings of the U.S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Vol. IV, 1-3 June 1966, with others
29. "Development of Lightweight Broadband Radomes from Slip-Cast Fused Silica," Technical Report AFAL-TR-67-56, April 1967, with others
30. "High-Strength, Broadband, Lightweight Silicon Oxide Radome Techniques," Reports on Contract F33615-67-C-1594, 1967-Present, with others
31. "Ceramic Systems for Missile Structural Applications," Reports on Contract N00017-67-C-0053, 1966-Present, with others
32. "Proceedings of the Tenth Symposium on Electromagnetic Windows," 29-31 July 1970, Co-Editor
33. "Historical Development of Radomes," Chapter 1 of RADOME ENGINEERING HANDBOOK - DESIGN AND PRINCIPLES (J. D. Walton, Jr., Editor) Marcel Dekker, Inc., New York, 1970

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

WALTON, JESSE D., Jr. -- Chief, High Temperature Materials Division, Engineering Experiment Station

Education

B.Cer.E., Georgia Institute of Technology	1950

Employment History

U.S. Navy	1943-1946
Ferro Corporation, Research Engineer	1950-1952
Georgia Institute of Technology	
Research Assistant and Assistant Research Engineer	1952-1955
Research Engineer	1955-1959
Special Research Engineer	1959-1965
Principal Research Engineer	1965-Present
Chief, High Temperature Materials Division	1968-Present

Experience Summary: Performed original research in the field of porcelain enameling at the Ferro Corporation. Actively engaged in ceramics research and development at Georgia Tech since 1952. Contributions in the study of stresses between enamel and metal, and for differential thermal analysis. Work of ceramic materials includes study of thermite reactions as a means for producing cermets, development of slip-cast fused silica for such uses as permanent foundry molds, heat treating dies and fixtures, telescope reflectors, radomes, and thermal protection of reentry bodies. Research in field of coatings includes vapor deposition and diffusion type intermetallic coatings, electrical insulation for wire, and arc-plasma-jet and flame sprayed coatings. Director of numerous projects on development and study of ceramic and ceramic-metal systems. Chairman, Ceramic-Metal Systems Division, American Ceramic Society 1965-66. Fellow of the American Ceramic Society.

Committees and Panels

General Chairman, U.S. Air Force/Georgia Tech Symposium on Electromagnetic Windows, 1966 and 1968; General Chairman, Tenth Symposium on Electromagnetic Windows, 1970; Member, Materials Advisory Board of the National Academy of Sciences, Ad Hoc Committee on Ceramic Processing; Chairman, Panel on Evaluation, Ad Hoc Committee on Ceramic Processing; Member ASTM Committee F-4, Surgical Implant Materials; Member ASTM Committee G-2, Erosion by Cavitation of Impingement; Member ASTM Committee C-22, Ceramic Coatings; Participant in Advisory Group for Aerospace Research and Development of NATO Specialists Conference on Design in Brittle Materials, London, England, 1967; Participant USNSF-Japan Seminar on Characterization of Ceramic Materials, Tokyo, Japan, 1969.

Current Fields of Interest

High-temperature ceramic, ceramic-metal, and intermetallic materials; arc-sprayed, flame-sprayed, vapor deposited, and diffusion-type coatings; design of special environmental equipment for the evaluation of high-temperature materials. Radomes for hypersonic and reentry vehicles. Evaluation of ceramic materials. Ceramic materials for surgical implants.

Major Reports and Publications

1. "Determination of Opacity by Means of a Translucency Meter," Am. Cer. Soc. Bulletin 29, No. 8, 282-285 (August 1950)
2. "Determination of Strains Between Enamel and Iron by Means of Split Rings," Journal of American Ceramic Society, 36, No. 10, 335, 341 (October 1953) with others
3. "Study of Strains Between Enamel and Iron as Related to the Physical Properties of Each," Journal of American Ceramic Society 37, No. 3, 153-160 (March 1954)
4. "Apparatus for Automatically Recording Strains Between Enamel and Metal," Journal of American Ceramic Society 38, No. 3, 114-118 (March 1955)
5. "New Method of Preparing Clay Samples for Differential Thermal Analysis," Journal of American Ceramic Society 38, No. 12, 432-443 (December 1955)
6. "Cermets from Thermite Reactions," Journal of American Ceramic Society 42, No. 1, 40-49 (January 1959), with others
7. "Experimental Application of Arc and Flame Sprayed Coatings," presented at the First Aerospace Finishing Symposium, Fort Worth, Texas, 7-9 December 1959, with others
8. "Ceramics for High Temperature Electrical Applications," presented at the Second National Conference on the Application of Electrical Insulation, Washington, D. C., 8-11 December 1959, with others
9. "The Use of Thermite Reactions to Produce Refractory Cermets," Ceramic Age 75, No. 6, 39-45 (June 1960), with others
10. "Materials Problems Associated with Uncooled Rocket Nozzles," Corrosion 16, No. 8, 371t-374t (August 1960), with others
11. "Fused Silica for Missile Components," Part I Ceramic Age 76, No. 2, 33-38 (August 1960); Part II Ceramic Age 76, No. 3 (23-28 September 1960)
12. "Ceramic Tooling and Honeycomb Brazing Fixtures for Supersonic Aircraft Production," American Ceramic Society Bulletin 39, No. 12, 740-742, 747-748 (December 1960), with others
13. "Present and Future Problem Areas for High Temperature Inorganic Coatings," American Ceramic Society Bulletin 40, No. 3, 136-141 (March 1961)
14. "Evaluation of Ceramic Materials Under Thermal Shock Conditions," Mechanical Properties of Engineering Ceramics, Interscience Publishers, New York, London, 149-171, 1961, with others
15. "Fused Silica Ceramics," Part I Ceramic Age 77, No. 5, 52-58 (May 1961); Part II Ceramic Age 77, No. 6, 53-58 (June 1961); Part III Ceramic Age 78, No. 1, 38-45 (July 1961)
16. "Fused Silica Refractories," 8th International Ceramic Congress, Det Berlingske Bogtrykkery A/S, Copenhagen, Denmark, 213-222, May 1962, with others
17. "Slip-Cast Fused Silica Radomes," Proceedings of the ASD-OSU Symposium on Electromagnetic Windows, Technical Documentary Report No. ASD-TDR-62-676 (Vol. I), July 1962, with others

Major Reports and Publications (continued)

18. "Slip-Cast Metal Fiber Reinforced Ceramics," American Ceramic Society Bulletin 41, No. 11, 778-780 (November 1962), with others
19. "Fused Silica-Hydrated Cements for Thermal Protection Systems," American Ceramic Society Bulletin 41, No. 12, 812-815 (December 1962) with others
20. "Spray-On Refractory Coatings System Considerations," presented at the National AIME Meeting, Pyro-Metallurgical Program, Dallas, Texas, February 1963, with others
21. "Slip-Cast Fused Silica," ML-TDR-64-195, October 1964, with others
22. "Slip Casting Large Fused Silica Radomes," Proceedings of the OSU-RTD Symposium on Electromagnetic Windows, (Vol. III) Session V, Paper D, 2-4 June 1964, with others
23. "Fused Silica for Reentry Radomes," Proceedings of the OSU-RTD Symposium on Electromagnetic Windows, (Vol. III) Session VI, Paper B, 2-4 June 1964, with others
24. "Slip-Cast Ceramic-Ceramic Fiber Composites," presented at the American Ceramic Society Symposium on "High Temperature Fibers and Fibrous Composites," Philadelphia, Pa., May 1965, with others
25. "Metal-Fiber Reinforced Ceramics," Fiber Composite Materials, American Society for Metals, Metals Park, Ohio, Chapter 10, 1965
26. "Properties of Ceramic Composites Containing Fibrous Reinforcements," PROCEEDINGS OF THE CONFERENCE ON NUCLEAR APPLICATIONS OF NON-FISSIONABLE CERAMICS (A. Boltax and J. H. Handwerk, eds.) 113-129, American Nuclear Society, Inc., Hinsdale, Illinois, 1966, with others
27. "Felted Ceramics," American Ceramic Society Bulletin 45, No. 6, June 1966
28. "A Hydrosonic Rain Erosion Test Program," Proceedings of the U.S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia, 1-3 June 1966, with others
29. "Techniques for Airborne Radome Design," AFAL-TR-66-391, Volume II, December 1966, Editor-in-Chief
30. "Rain Erosion of Ceramics at High Mach Numbers," Proceedings of the 2nd Conference on Rain Erosion, Meersburg, West Germany, 16-18 August 1967, with others
31. "Rain Erosion at High Mach Numbers," International Conference on Electromagnetic Windows, Paris, France, 6-8 September 1967, with others
32. "Ceramic Processing," Publication 1576 National Academy of Sciences, Washington, D. C., 1968, Chapter 5, Report of the Panel on Evaluation, with others
33. "Sintered Fused Silica," Interceram, Freiburg, Germany, Vol. 17, No. 2, 121-122, 133, June 1968
34. "Evaluation of Ceramics, the Significance of Testing," Proceedings of the First U.S.-Japan Seminar on Basic Science of Ceramics, "Characterization of Ceramic Materials," Tokyo, Japan, 24 February - 1 March 1969

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35. "Mechanical Properties of Oxide Ceramics," Meeting of ASTM Committee F-4 on Surgical Implant Materials, Memphis, Tenn., 20 November 1969
36. "Supersonic Rain Erosion Resistant Ceramic Coatings," Proceedings of the Air Force Symposium, Miami, Florida, 18-22 May 1970
37. "Evaluation of Ceramic Coatings for Rain Erosion Protection," Proceedings of the U.S. Air Force-Georgia Tech Symposium on Electromagnetic Windows, Atlanta, Georgia 29-31 July 1970, with others
38. "Proceedings of the Tenth Symposium on Electromagnetic Windows," 29-31 July 1970, Co-Editor
39. "Evaluation of Ceramic Coatings for Rain Erosion Protection," Proceedings of the Third International Conference on Rain Erosion and Associated Phenomena, Elvetham Hall, England, 11-13 August 1970, with others
40. RADOME ENGINEERING HANDBOOK - DESIGN AND PRINCIPLES, Marcel Dekker, Inc., New York, 1970, Editor